(NASA-CR-173691) SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS: MISSION REQUIREMENTS Final Study Report (McDonnell-Douglas Corp.) 68 p HC A04/MF A01 CSCL 22B G3/18

N84-27817

Unclas 00941

Space Station Needs, Attributes and Architectural Option Final Study Results

MISSION REQUIREMENTS

April, 1983

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MISSION REQUIREMENT TOPICS

- Mission Model and Methodology
- Science and Applications
- Commercial/Technology Mission Summary
- Operations Analysis
- Benefits/Prioritization Analyses
- Integrated Mission Requirements
- Role of Man

MISSION MODEL EVOLUTION

PHASE I RESULTS (MIDTERM)

95 Space Station Missions
- DOD
- Commercial
- Technology
- Operations
- Science & Applications

174 Satellite Missions
- For Traffic Model

PHASE II TASKS

- Phase I Critique
- More User Contacts
- Analyses:
  - Benefits
  - OTV/TMS
  - Man vs Unmanned
  - Prioritization
  - Spacelab Missions
  - Foreign Missions
- Iterate Model

FINAL OUTPUT

88 Space Station Missions
- Commercial
- Technology
- Operations
- Science & Application

139 Satellite Missions
- For Traffic Model

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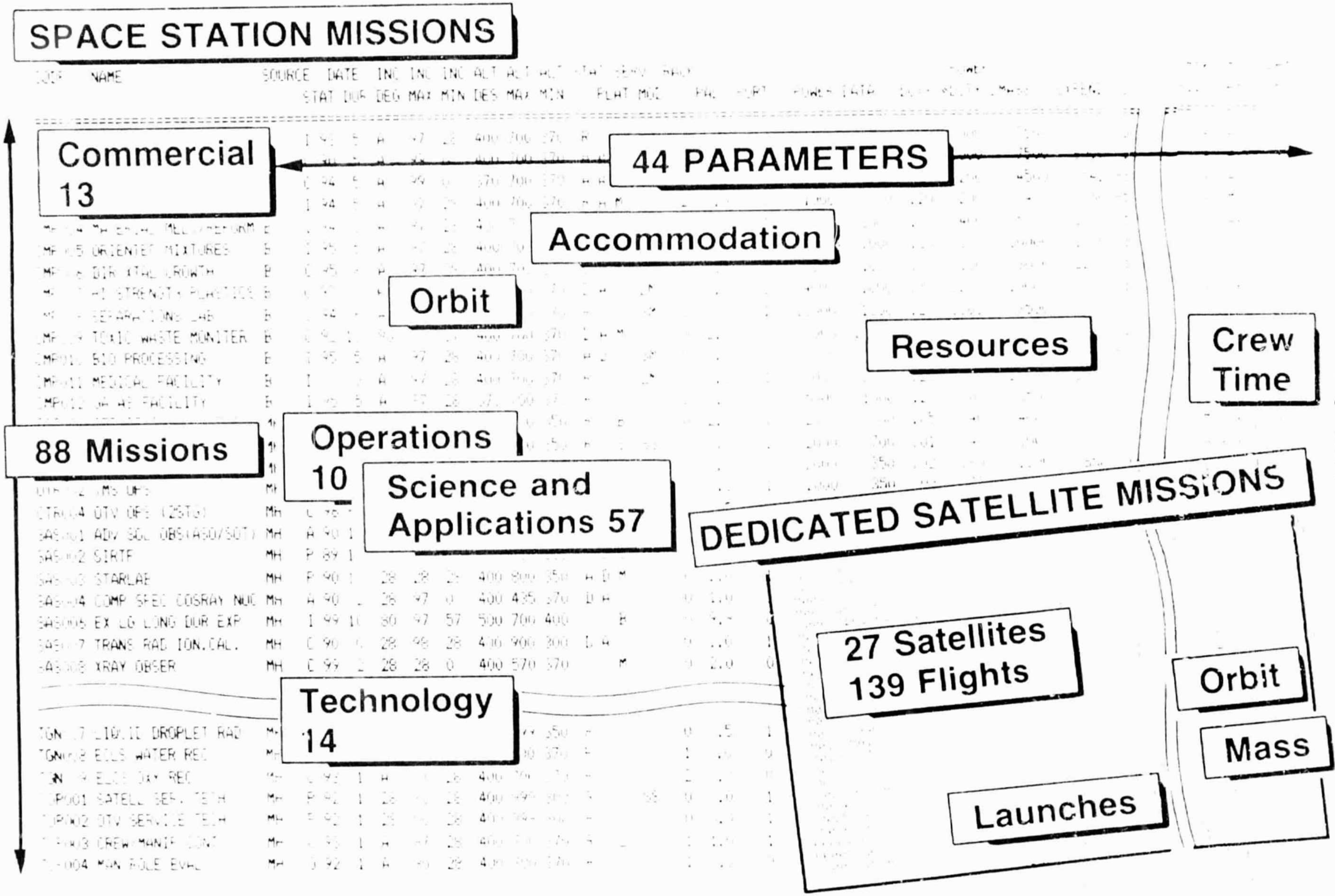
MISSION DATA BASE



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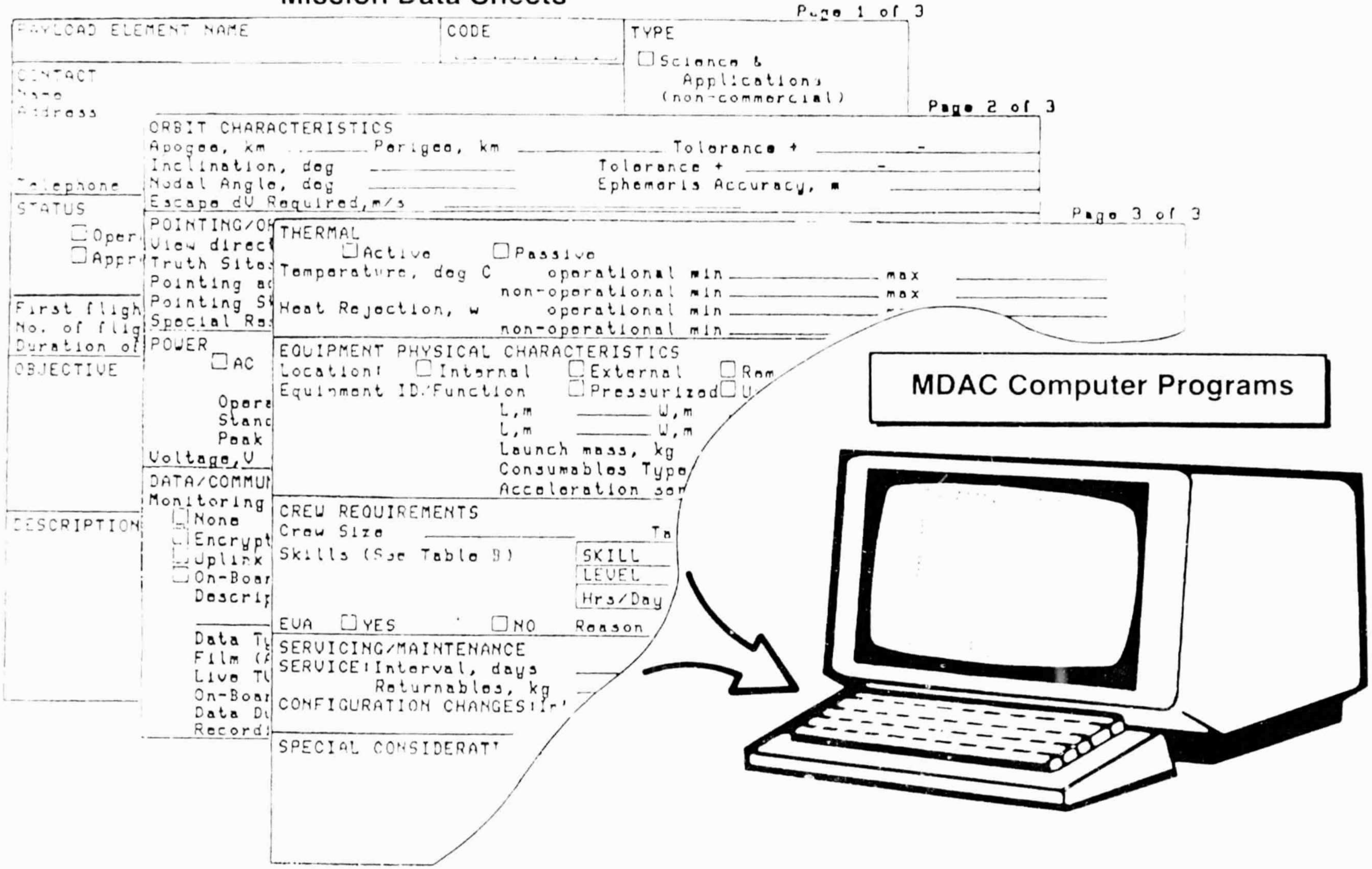
DATA BASE PROCESSING

Mission Data Sheets



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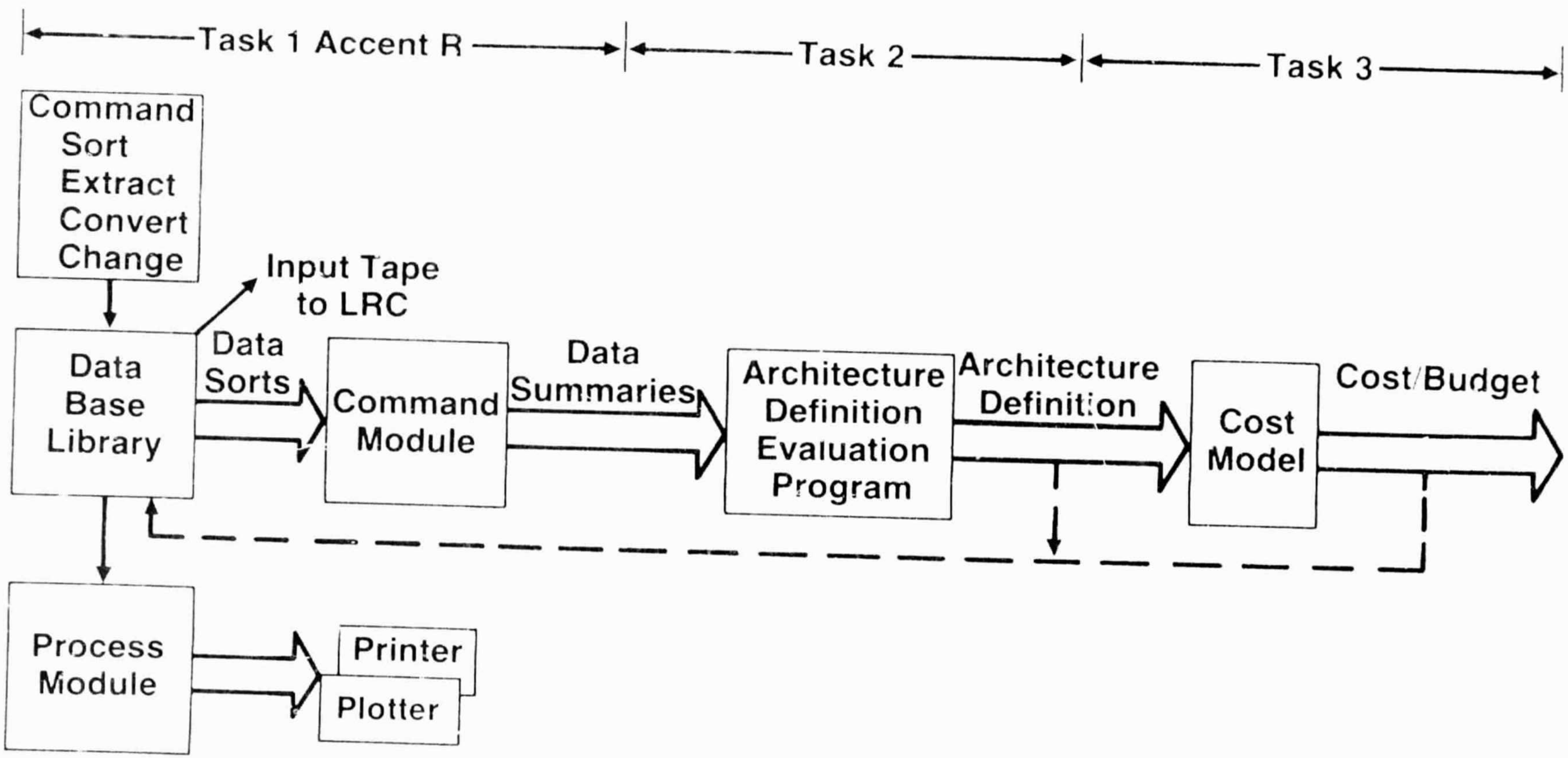
VGB579

COMPUTERIZED DATA FLOW



SCIENCE AND APPLICATIONS MISSION

57 TOTAL

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ASTROPHYSICS 19

- SAS001 ADV SOL OBS(ASO/SOT)
- SAS002 SIRTF
- SAS003 STARLAB
- SAS004 COMP SPEC COSRAY NUC
- SAS006 EX LG LONG DUR EXP
- SAS007 TRANS RAD ION.CAL.
- SAS008 XRAY OBSER
- SAS009 SPACE TELESC
- SAS010 HIRES X&G-RAY SPEC
- SAS011 XRAY TIMING EXPL
- SAS012 SOLAR INT DYNAMICS
- SAS013 ADV XRAY ASTROFAC
- SAS014 LAMAR(HTM)
- SAS015 VLBI
- SAS016 LRG DELP REFL
- SAS017 GAMMA RAY OBS
- SAS018 HIGH ENER ISO EXP
- SAS019 SOLAR COR DYN
- SAS020 COSMIC RAY OBS

COMMUNICATIONS 3

- SCM001 REMOTE SENSING RFI
- SCM002 ORB STANDARDS FACK
- SCM003 COMM RESEARCH FAC

ENVIRONMENTAL 8

- SEE001 OCEAN PAYLOAD
- SEE002 ATMOS COMP
- SEE003 UPPER ATMOS RES
- SEE004 SPACE PLASMA PHYSICS
- SEE005 ZERO G CLOUD PHYSICS
- SEE006 MET. RES. PKG
- SEE007 ATM DYNAMICS&RAD
- SEE008 OP CIVIL MET

EARTH AND PLANETARY 16

- SEP001 SAR
- SEP002 MULTISPECT [illegible]
- SEP003 MAG FIELD MAPPER
- SEP004 PASS MICROWAVE RAD
- SEP005 LARGE FORMAT CAMERA
- SEP006 IMAGE SPECTROMETER
- SEP007 LUMINESCENCE DET
- SEP008 LASER RANGING
- SEP009 LANDSAT D-D'
- SEP010 RADAR ALT
- SEP011 ACT FLUOR SPECT
- SEP012 PLAN SPECT TELE
- SEP013 IR SPECT
- SEP014 FAR IR SPECT
- SEP015 EXTRA SS DET
- SEP016 PLANETARY PROC LAB

LIFE SCIENCES 6

- SLS001 PRIMATE EXP FAC
- SLS002 PLANT BIO/LS FACIL
- SLS003 RODENT EXP FACIL
- SLS004 ORB QUARANTINE
- SLS005 EXP MED TRENT FAC
- SLS006 HUMAN EXP FAC

MATERIALS PROCESSING 5

- SMP001 MATERIALS PROC [illegible]
- SMP002 MATERIALS EXP CARR
- SMP003 MATERIALS EXP ASS
- SMP004 WAKE SHIELD EXP
- SMP005 ULTRAVACUUM FAC

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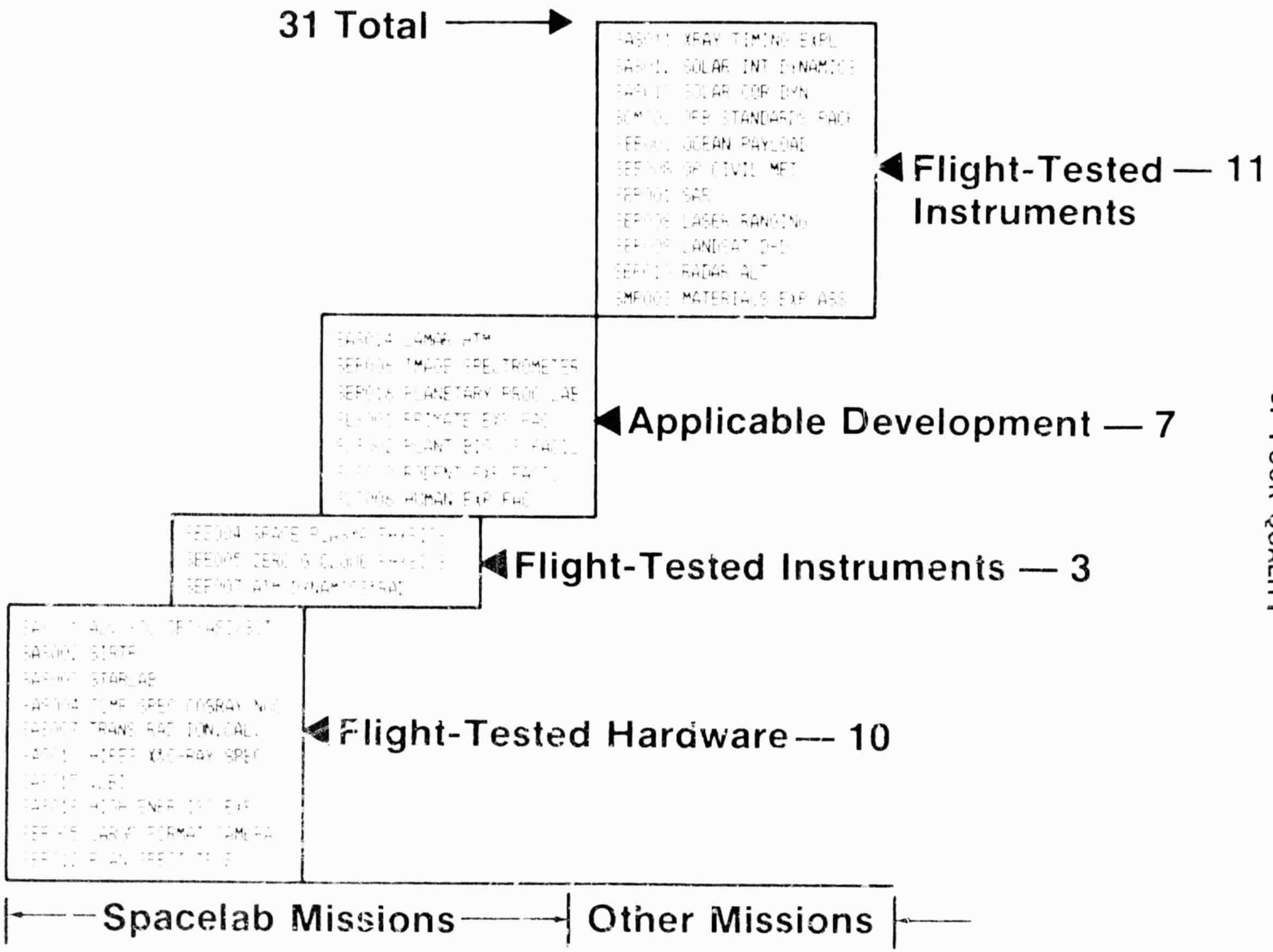
VGB639

LEGACY MISSIONS



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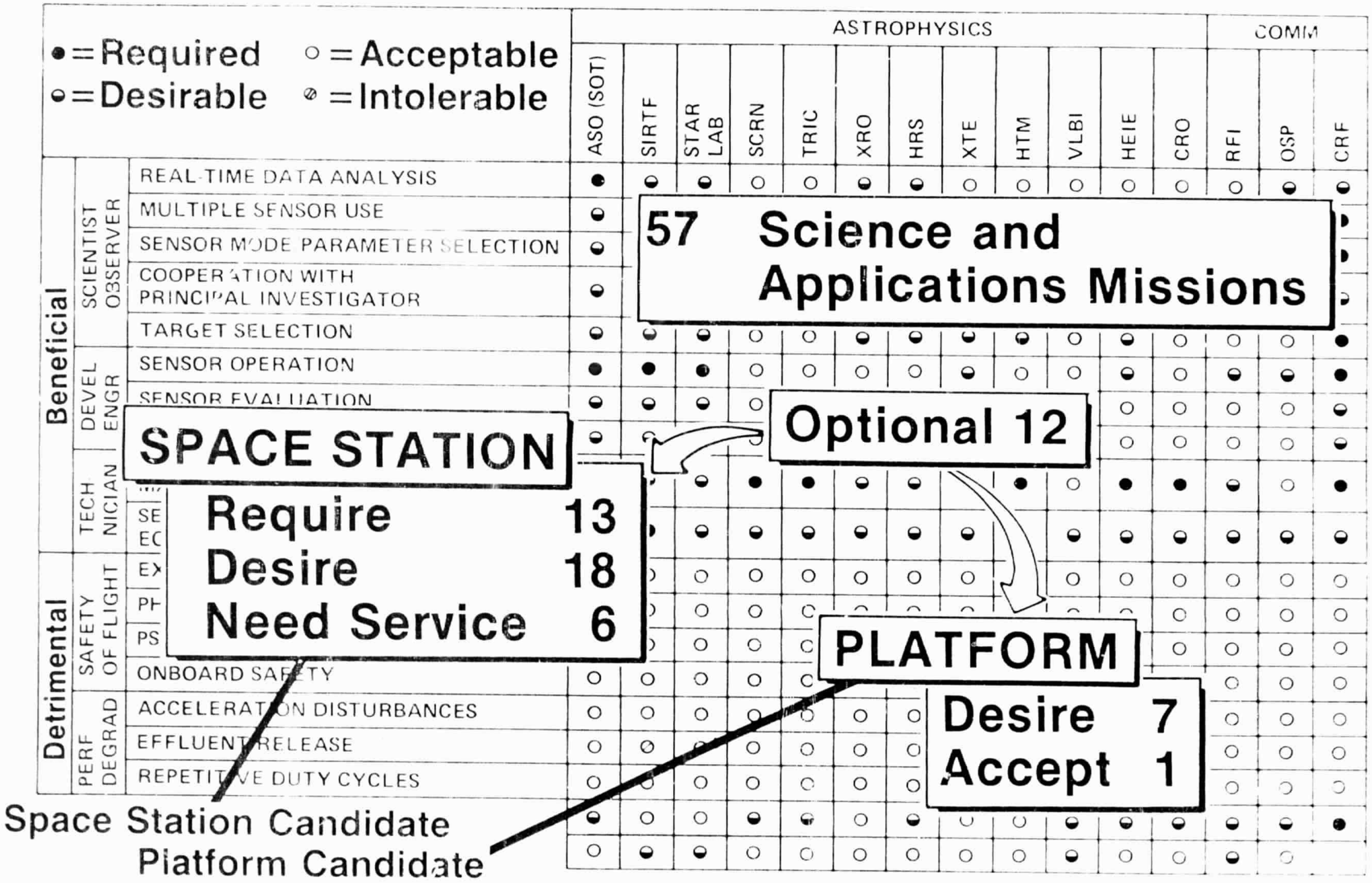
EVALUATION OF MAN IN-ORBIT INFLUENCES

VGB617



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ACCOMMODATION REQUIREMENTS — SCIENCE AND APPLICATIONS MISSIONS

57 TOTAL

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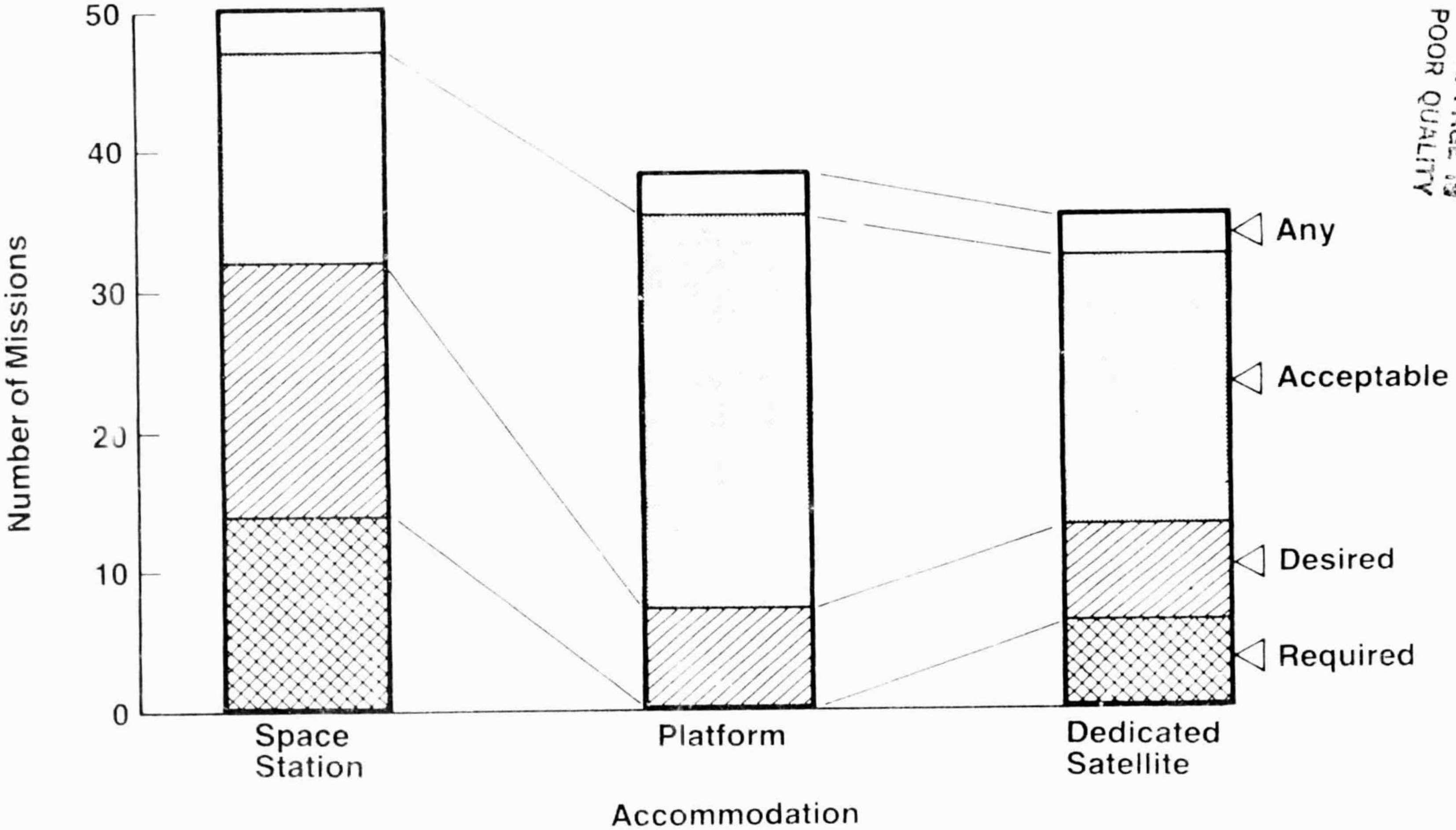

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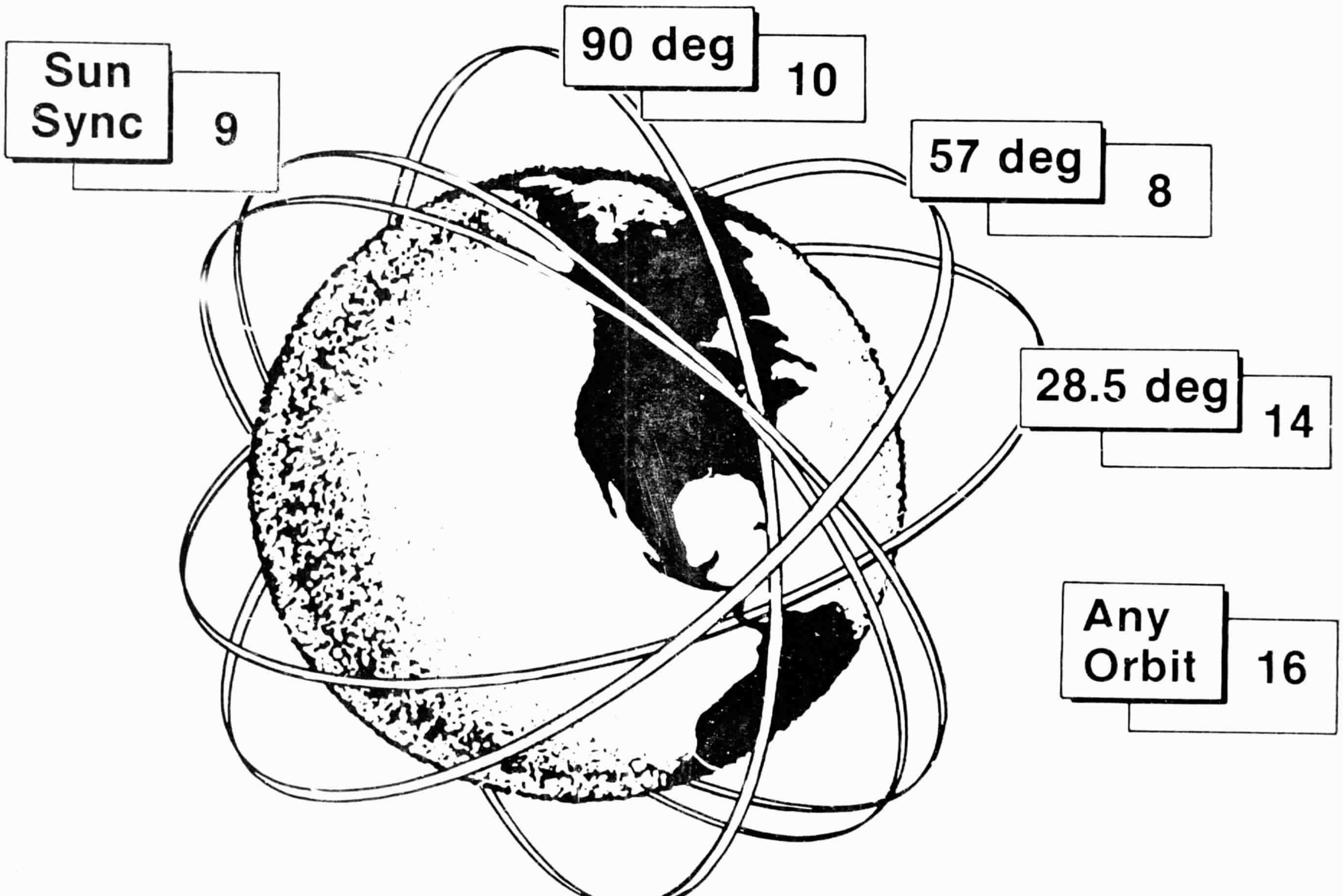
ORBIT REQUIREMENTS SCIENCE AND APPLICATIONS MISSIONS

VGB562



INCLINATION REQUIREMENTS — SCIENCE AND APPLICATIONS MISSIONS

57 TOTAL

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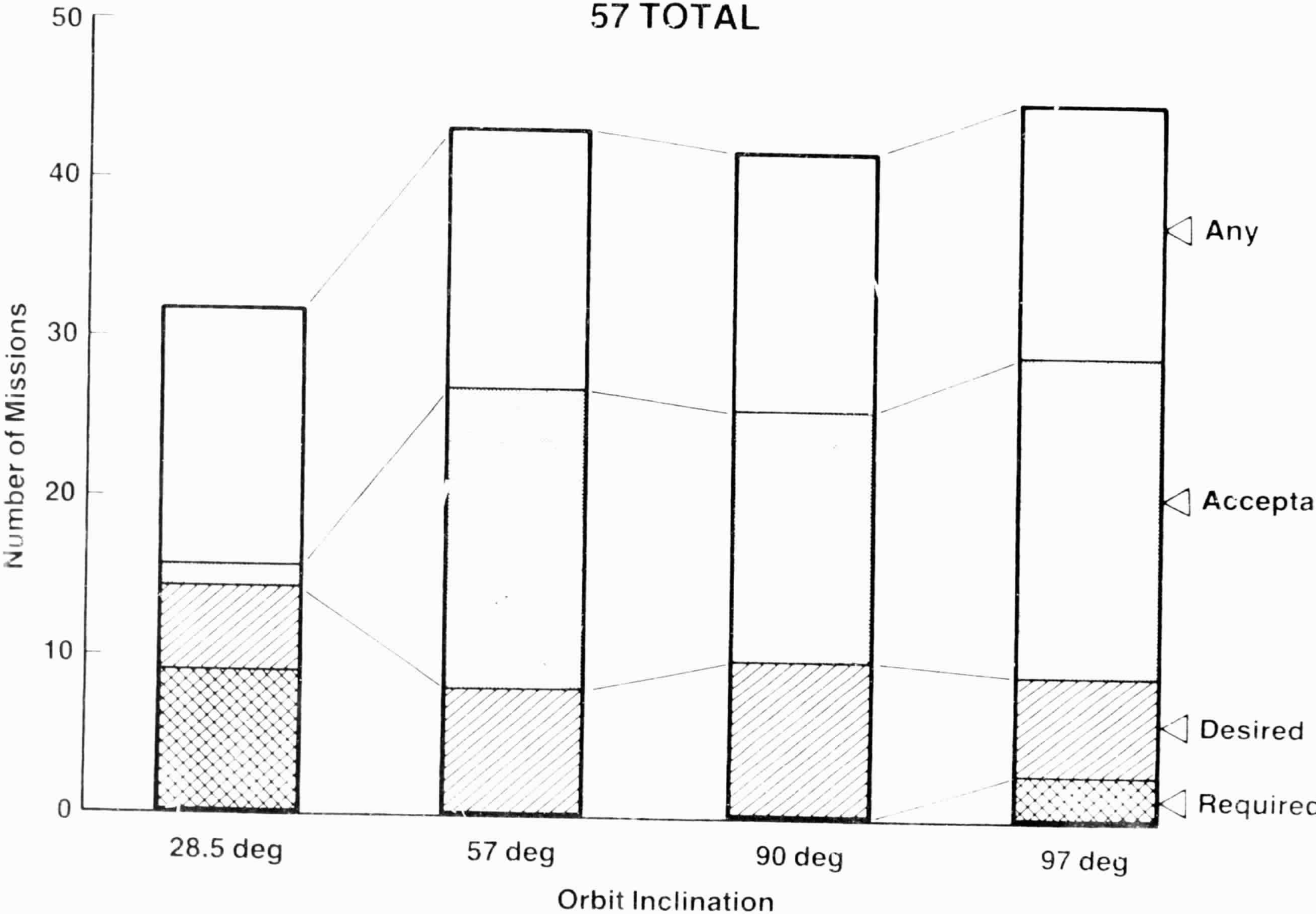
VGB768



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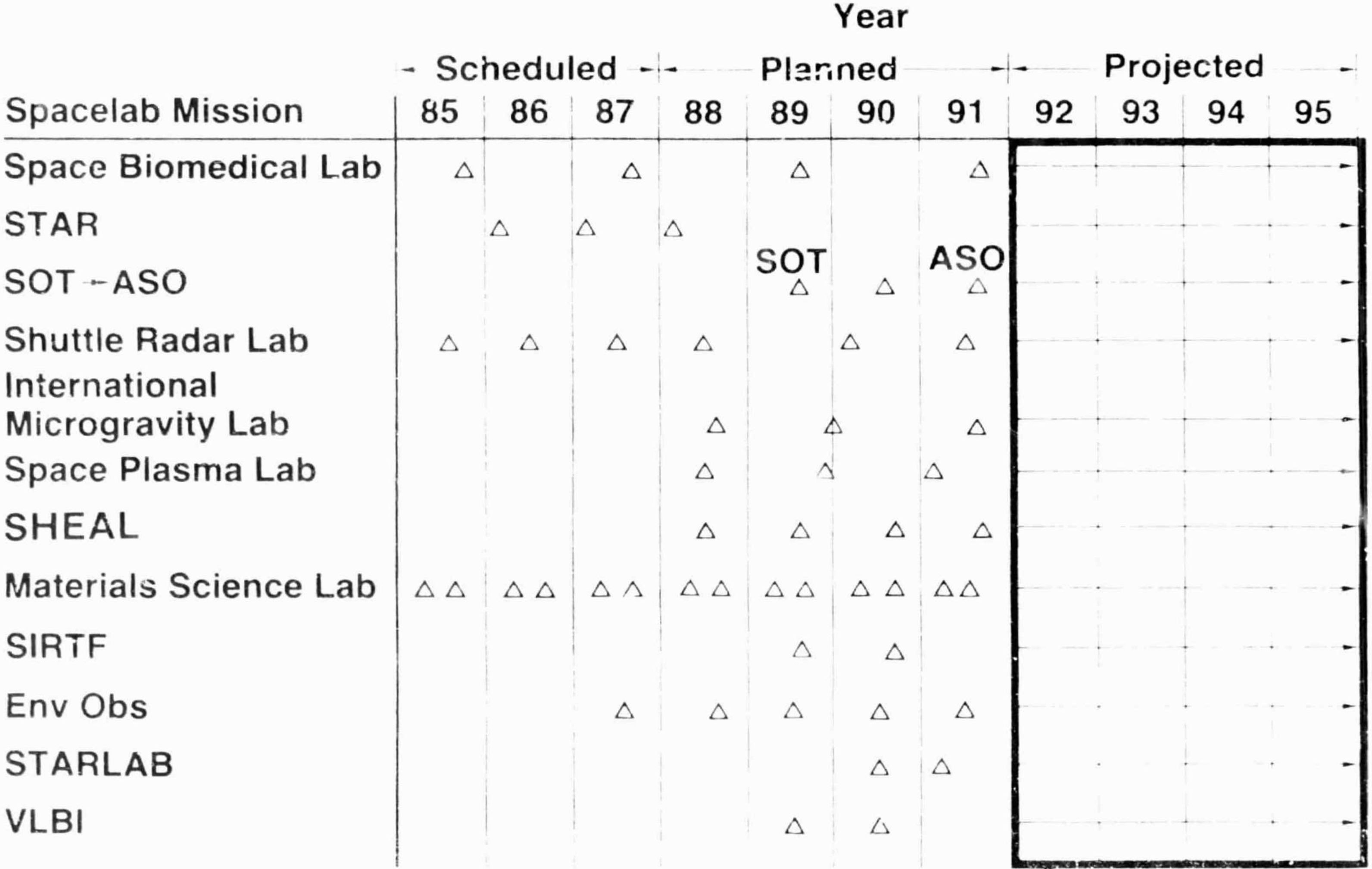
SPACELAB MISSION LAUNCH

VGB582



Candidate Space Station Missions

- 11 Mission/yr
- 4 Shuttle Flight/yr (Equiv) Saved

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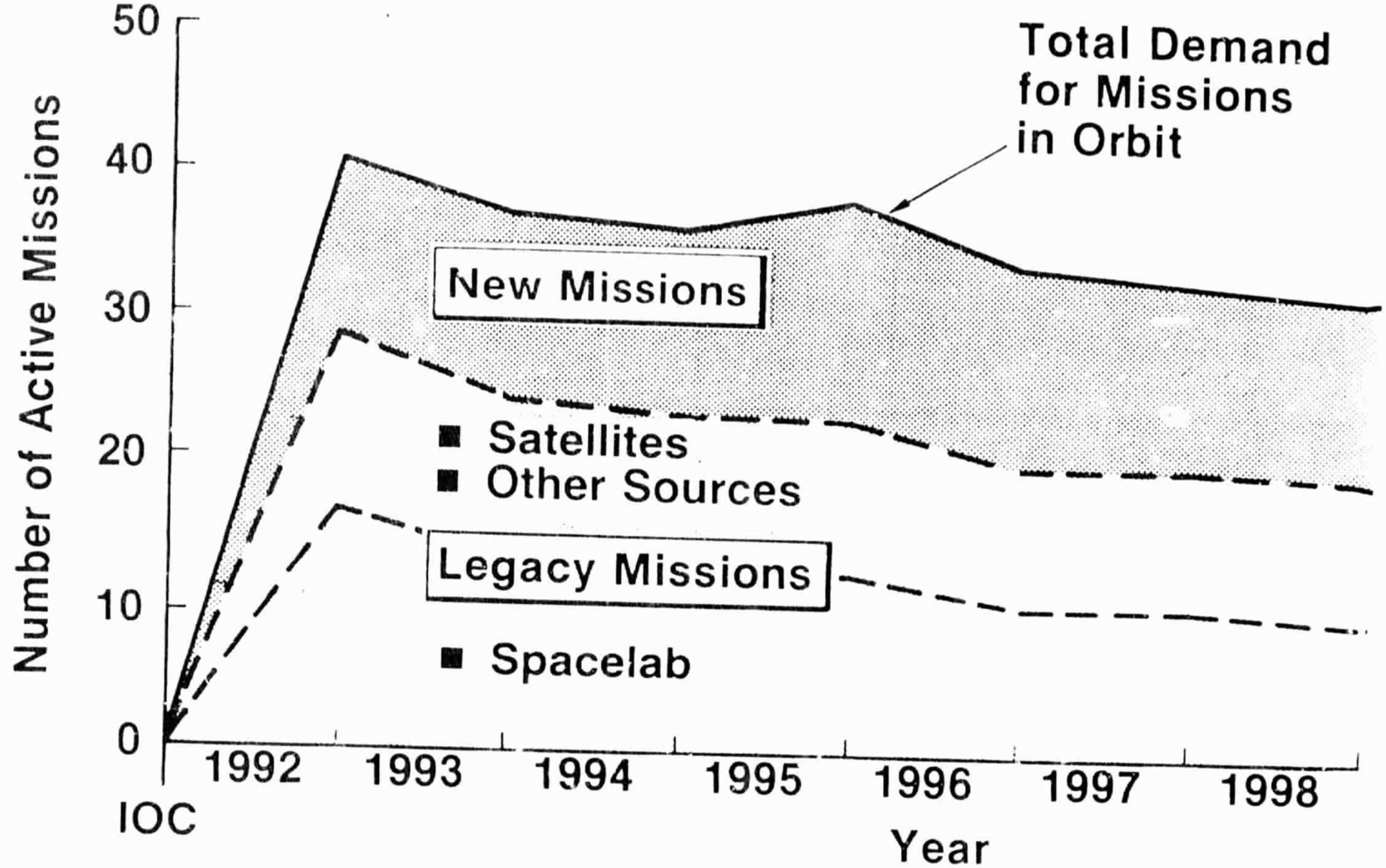
MISSION DEMAND
SCIENCE AND APPLICATIONS



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MISSION COST ESTIMATES
SCIENCE AND APPLICATIONS

GB685

EQUIPMENT STARTS

- New
  1.3/yr $200 Million/yr
- Spacelab Legacy
  2.7/yr $150 Million/yr
- Other Legacy
  1.5/yr $50 Million/yr

Assumed Budget
$400 Million/yr

1987 — 1992

EQUIPMENT STARTS

- New
  1.2/yr $210 Million/yr
- Other Legacy
  0.4/yr $30 Million/yr

OPERATIONS

- 25 Missions/Yr (Average) $360 Million/yr

Assumed Budget
$600 Million/yr

1993 — 2000

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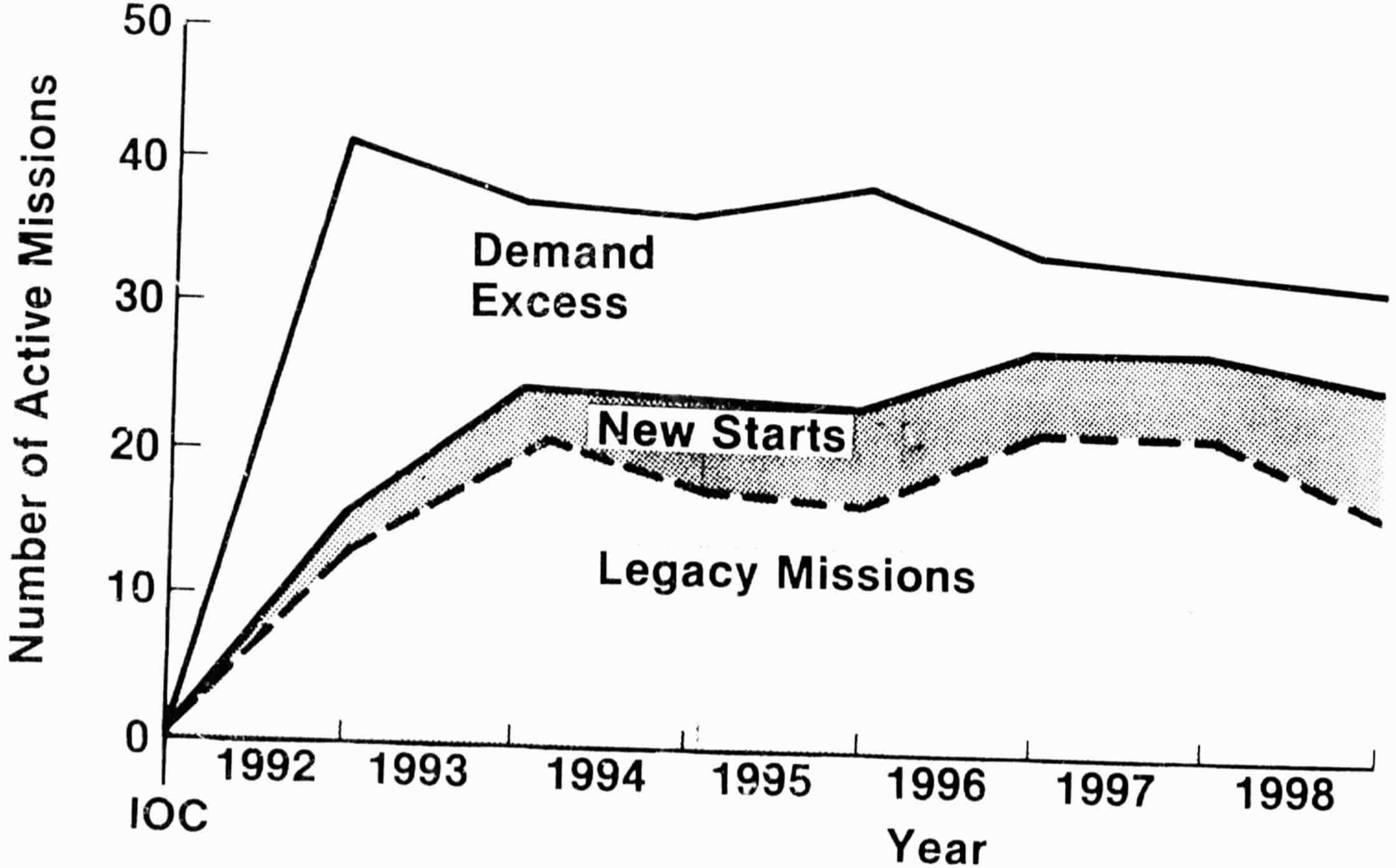
VGB563A

BUDGET-CONSTRAINED SCIENCE AND APPLICATIONS PROGRAM



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VGB583

SCIENCE AND APPLICATIONS MISSIONS PRIORITIES AND TIME PHASING

- PRIORITY 1
  - 1992
    - ASO ■ XTE ■ SAR ■ MLA ■ Pass MW Rad
    - LFC ■ Radar Alt ■ MEA ■ ST ■ AXAF ■ LANDSAT
- PRIORITY 2
  - 1992
    - SIRTF ■ Starlab ■ SCRN ■ OSP ■ Ocean
    - SPP ■ PBLF ■ REF ■ HEF ■ MPL ■ MEC
    - GRO ■ UARS ■ OP Civ Met
  - 1993-1996
    - VLBI ■ Atm Dyn
    - IS ■ PEF
  - 1997-1999
    - CRO
- PRIORITY 3
  - 1992
    - TRIC ■ HEIE ■ Atm Comp ■ Cloud Phys
    - Met Res ■ Laser Rang ■ SIDM ■ HTM
  - 1993-1996
    - SCDM ■ Lum Det
    - PST ■ IRST ■ LDR
  - 1997-1999
    - XRO
- PRIORITY 4
  - 1992
    - HRS ■ RFI ■ CRF
    - MFM ■ WS
  - 1993-1996
    - Fluor Spec ■ XSST
    - EMTF ■ Ultravac
  - 1997-1999
    - XLLDEF ■ FIRST
    - PPL ■ OQF

MATERIALS PROCESSING LABORATORY
SMP001

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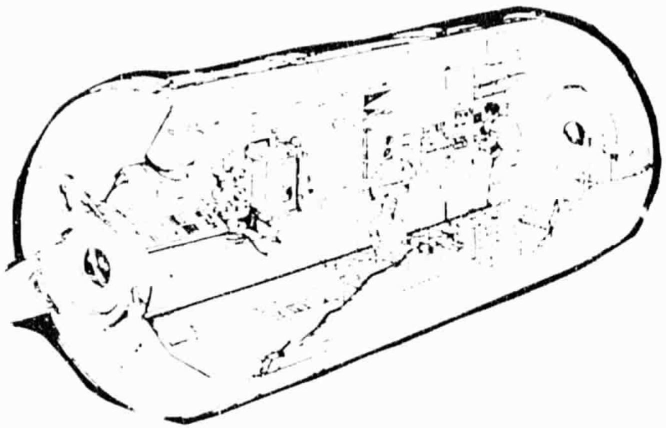
VGB770



CHARACTERISTICS

- Manned Laboratory
- Materials R&D
- Small-Scale ;Production

CONSIDERATIONS AND REQUIREMENTS

- Capability for Limited Evaluation of Test Results
- 10^{-3} to 10^{-6} g Required for Many Experiments
- Access to Space Vacuum Required for Some Processes
- Flexibility to Make Many Different Test Setups From Basic Equipment

MISSION DATA

Status: Candidate

Earlist Launch: 1993

Mass: 12300 kg

Preferred Orbit: Any

Power: 12 kW Peak, 6 kW Average

Data Rate: 10 Kbps Peak, 5 Kbps Average

Accommodation: Station — R
Platform — U
Satellite — U

Operations:

	Hrs/Year	Ops/Yr
Scientist/Observer —	100	400
Operator/Engineer —	100	400
Technician —	100	400

Launch Volume: Long Module (6m)

Peak Rate Duty Cycle: 0.5

Priority Rating: 3

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RESULTS/CONCLUSIONS SCIENCE/APPLICATIONS

MISSIONS

- 57 Defined, Prioritized, Time Phased
- 31 Legacy (Spacelab, etc.)
- 13 Service Opportunities (6 Planned) 2 Approved, 11 New Starts
- 24 New Starts (2/yr)

ORBIT INCLINATION

- 28.5 deg Required (Service and Astrophysics)
- Sun Sync Best Statisfies Remainder
- 57 deg Strong Candidate

STUDIES NEEDED

- Accomplishment vs Cost 57, 90, Sun Sync
- Integration — Pointing, Contamination, FOV, etc.
- Prioritization/Schedule Review
- Role of Man

FACILITIES

- Manned Station Required
  - — 4 Modules
  - — 2.5 Crew
  - — Multiple Pointing
- Platform Desired
- Power — To 50 kW
- Data — To 180 Mbps

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VGB461

COMMERCIAL MISSION OPPORTUNITIES

13 MISSIONS IN MDAC MISSION MODEL

			STAT		DUR	DEG
[illegible]	MATERIALS RES FAC	MH	I	93	5	A
CMP001	ELECTROPHORETIC PRO	MH	C	90	5	A
CMP002	SILICON RIBBON MAN	MH	C	94	5	A
CMP003	ELECTRONIC CIR ELEM	MH	I	94	5	A
CMP004	MATERIAL MELT/REFORM	B	I	94	8	A
CMP005	ORIENTED MIXTURES	B	I	95	5	A
[illegible]	DIR XTAL GROWTH	B	C	95	8	A
[illegible]	HI STRENGTH PLASTICS	B	C	97	8	A
[illegible]	SEPARATIONS LAB	B	C	94	6	A
[illegible]	TOXIC WASTE MONITOR	B	C	92	10	90
CMP010	BIO PROCESSING	B	I	95	5	[illegible]
CMP011	MEDICAL FACILITY	B	I	97	10	A
[illegible]	GA AS FACILITY	B	I	95	5	A

PROCESSES

- Electrophoresi
- Electron Beam
- Containerless
- Oriented Mixtu
- Crystal Growth
- Rapid Tempera
- Unidirectional
- Biomaterials P
- Medical Proced
- Gallium Arseni

TARGET USERS

- AT&T • Monsanto
- Eli Lilly • Fluor
- IBM • Eastman Kodak
- Union Carbide • Nitinol
- Allegheney International
- Johnson Matthey • Eaton
- Calcitek • Staley
- Tucker Anthony • GTI
- DuPont • John Deere
- Bethlehem Steel
- Celanese • MDC
- Hoffmann-LaRoche
- Baxter Travenol
- Inco • Johnson & Johnson
- Ford Aerospace • Comsat
- Microgravity Research
- Geosat Companies

CRITERIA FOR SELECTION

- High Market Value
- High Value Per Pound
- Uses Properties of Space
- Long Market Life — Low Obsolescence Rate

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COMMERCIAL MISSIONS

CODE	NAME	DATE	DUR	STAT PLAT	SERV MOD	RACK	PAL	PORT	POWER	DATA	DUTY	POWER *DUTY	LMASS	EXPEND	G	CREW SIZE	HRS DAY	DAYS YR
CIR001	MATERIALS RES FAC	93	5	R	SM	0	.0	1	25000	10000	.20	5000	7500	10	-3	2	2.00	60
CMP001	ELECTROPHORETIC PRO	90	5	A A M	SM	0	.0	1	15000	1000	.80	12000	7500	6000	-3	1	2.00	50
CMP002	SILICON RIBBON MAN	94	5	A A	SM	0	.0	1	15000	1000	.80	12000	4500	542	-3	1	2.00	50
CMP003	ELECTRONIC CIR ELEM	94	5	R A M		2	.0	0	1000	10	.20	200	470	50	-5	1	4.00	70
CMP004	MATERIAL MELT/REFORM	94	8	R	SM	0	.0	1	12000	1000	.20	2400	5000	1000	-5	1	2.00	260
CMP005	ORIENTED MIXTURES	95	5	D A	SM	0												50
CMP006	DIR XTAL GROWTH	95	8	D A		2												260
CMP007	HI STRENGTH PLASTICS	97	8	D A	LM	0												[illegible]
CMP008	SEPARATIONS LAB	94	6	R	SM	0												
CMP009	TOXIC WASTE MONITOR	92	10	D A M		0	2.0											
CMP010	BIO PROCESSING	95	5	A D	SM	0	.0											
CMP011	MEDICAL FACILITY	97	10	R	LM	0	.0											
CMP012	GA AS FACILITY	95	5	R		2	.0											

SIZING REQUIREMENT

- Size — Large Modules
- Resupply — to 6000 kg/yr
- Power — to 25 kW
- G-Level — 10^{-3} to 10^{-5}
- Crew — 1 to 3
- Proprietary Operations

COMMERCIAL MISSION SUMMARY

- New Candidate Users Identified
- Benefits and Market Potential Large
- Followup Essential
- Concept-to-Market Process Takes Years
- Space Research Laboratory Required
- Manned Interaction Essential

Users Need Incentives, Proprietary Protection, and Manned Space Facilities

Requirements on Space Station

- High Power
- Crew Participation
- Continuous Operations
- Pressurized Lab — Vacuum Access
- Microgravity

SPACE OPERATIONS AND TECHNOLOGY MISSIONS

Benefits:
- Economic
- Technological

- Reduced STS Flights
- Lower Transportation Costs
- Spacecraft Reuse
- Larger Systems
- Multiuse Systems
- Commercial Attraction
- Enabling Technology

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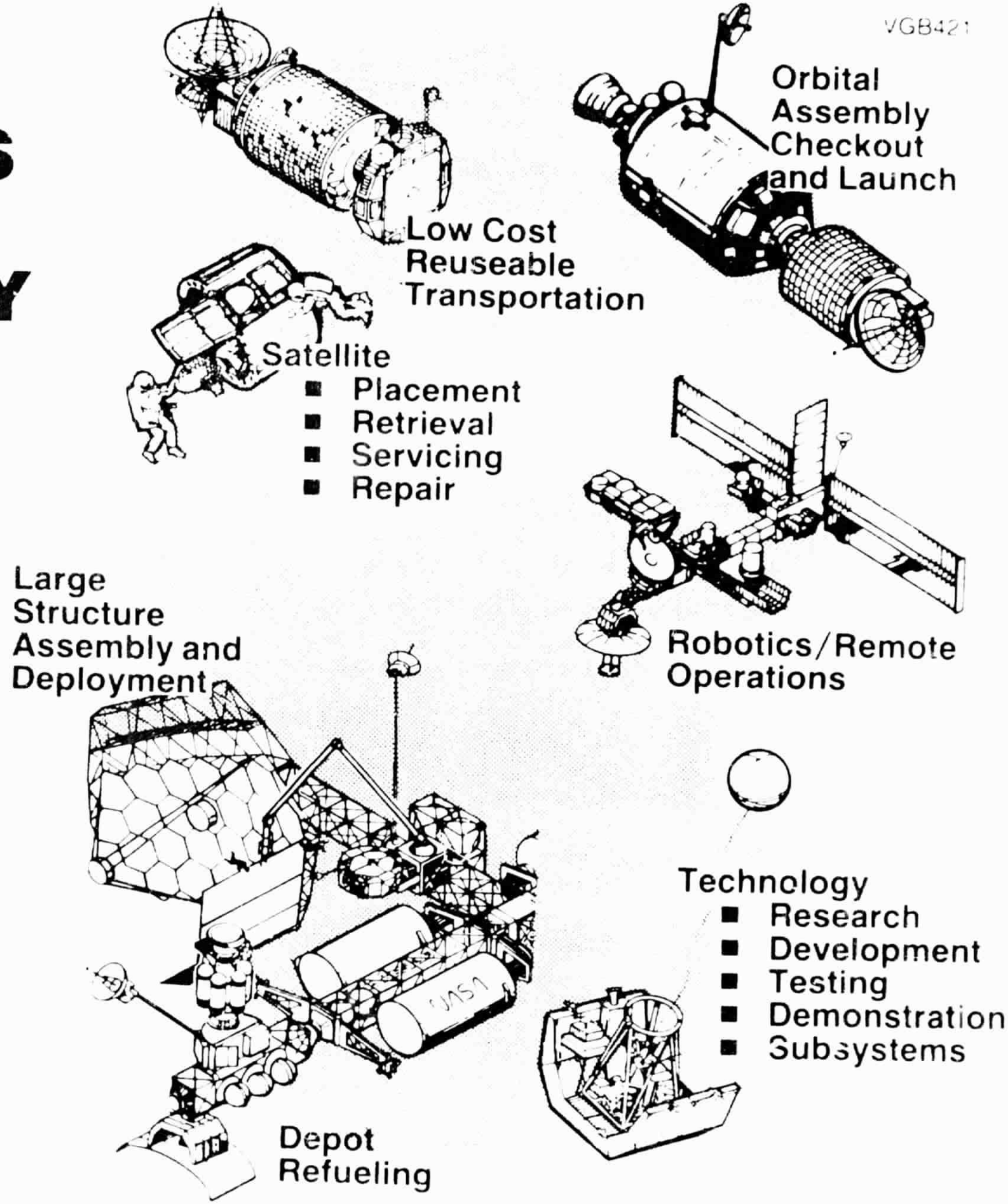

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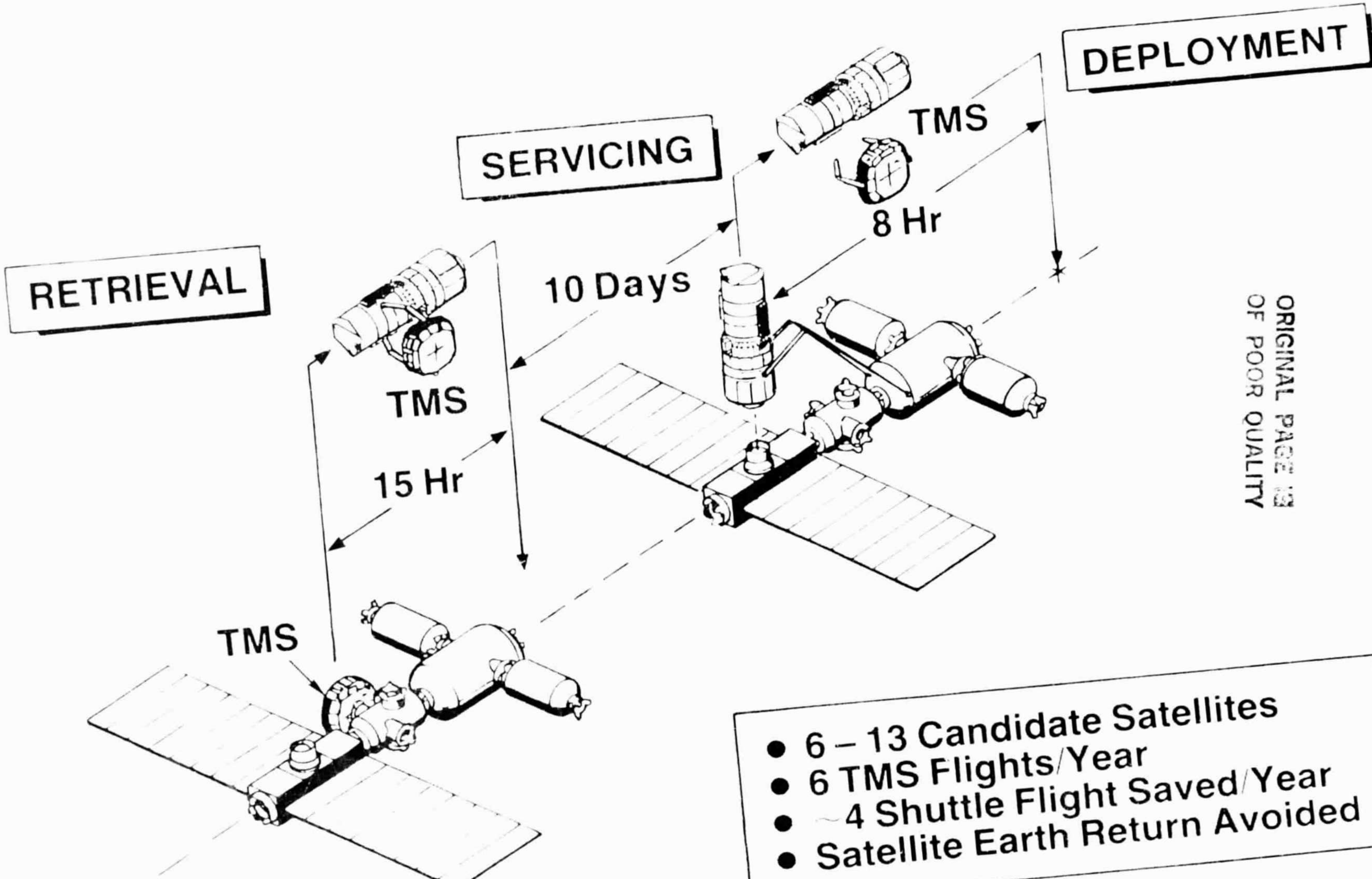
SATELLITE SERVICING



- 6 – 13 Candidate Satellites
- 6 TMS Flights/Year
- ~4 Shuttle Flight Saved/Year
- Satellite Earth Return Avoided

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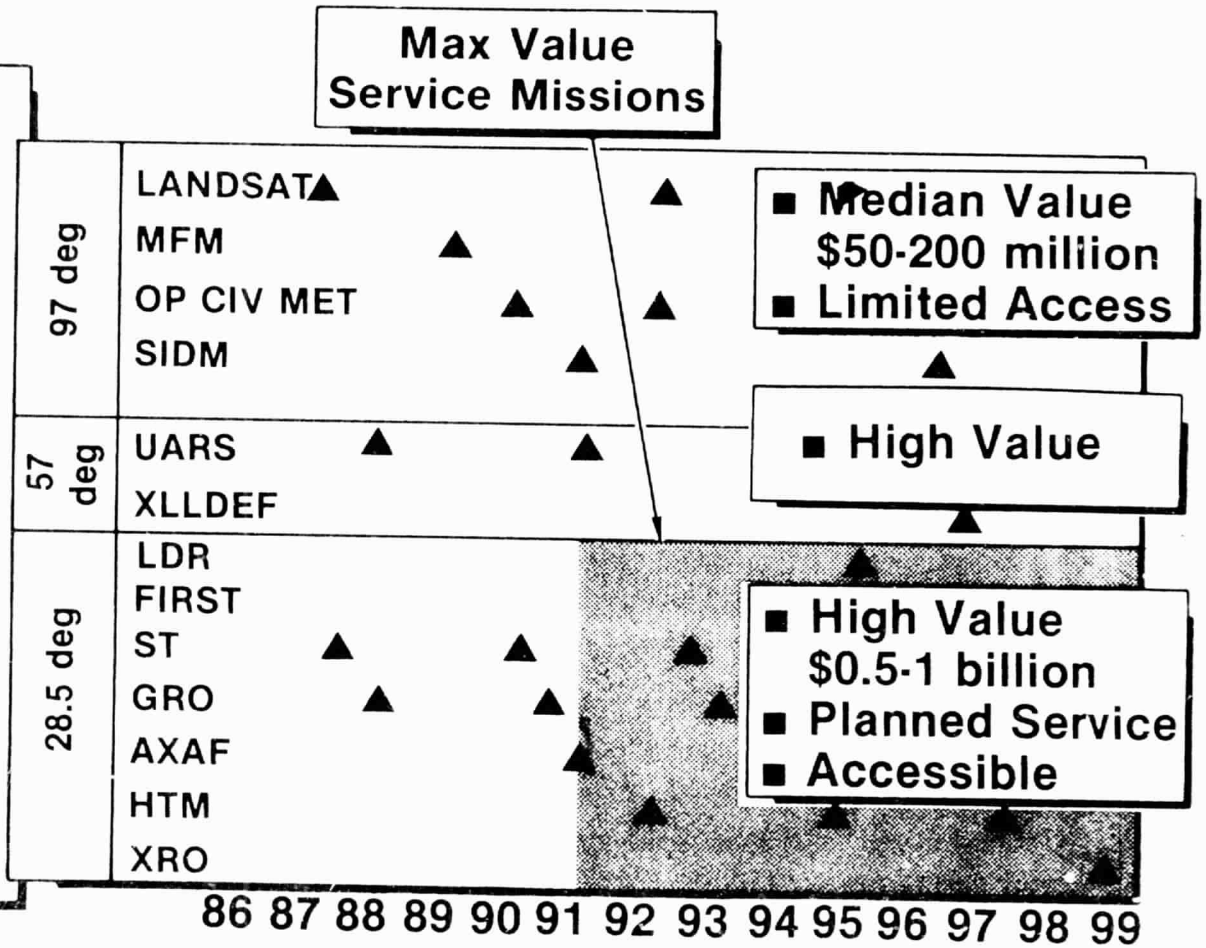
VGB560

SATELLITE SERVICING MISSIONS

Satellite Servicing Evolution

- Orbiter EVA
- TMS/Orbiter EVA
- TMS/Space Station EVA
- TMS/Space Station Hangar
- TMS Sortie Robotics
- OTV/TMS Sortie Robotics
- Manned OTV



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VGB660

TECHNOLOGY DEVELOPMENT IN ORBIT

MISSION TECHNOLOGY

Space Station Mission Drivers

- ROTV
- Satellite Servicing
- Large Structure Assembly and Deployment
- Large Antennas

SELECTED TECHNOLOGY MISSIONS

- Satellite Service Technology
- OTV Service Technology
- Crew Manipulator/Robotics
- Zero-g Antenna Range
- Fluid Storage & Mgmt
- Evaluation of Man's Role
- Large Structure-Construction
- Large Structure-Control

SPACE STATION REQUIREMENTS

- Crew
- EVA/MMU
- RMS
- Voice/Video
- External Ports
- Instrumentation

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VGB661

TECHNOLOGY DEVELOPMENT IN ORBIT

SUBSYSTEM TECHNOLOGY

Space Station Program Drivers

- Cost
- Logistics
- Long Life
- Reliability
- Performance

SELECTED TECHNOLOGY MISSIONS

- ECLS H_2O Recovery
- ECLS O_2 Recovery
- Advanced Technology Radiator
- Materials and Coating Technology
- Laser Comm and Tracking
- Tether Dynamics
- Evaluation of Man's Role
- Large Structure-Construction
- Large Structure-Control

SPACE STATION REQUIREMENTS

- Crew
- EVA/MMU
- Modular Subsystems
- Shop and Test Equip.
- Voice/Video
- Inst.

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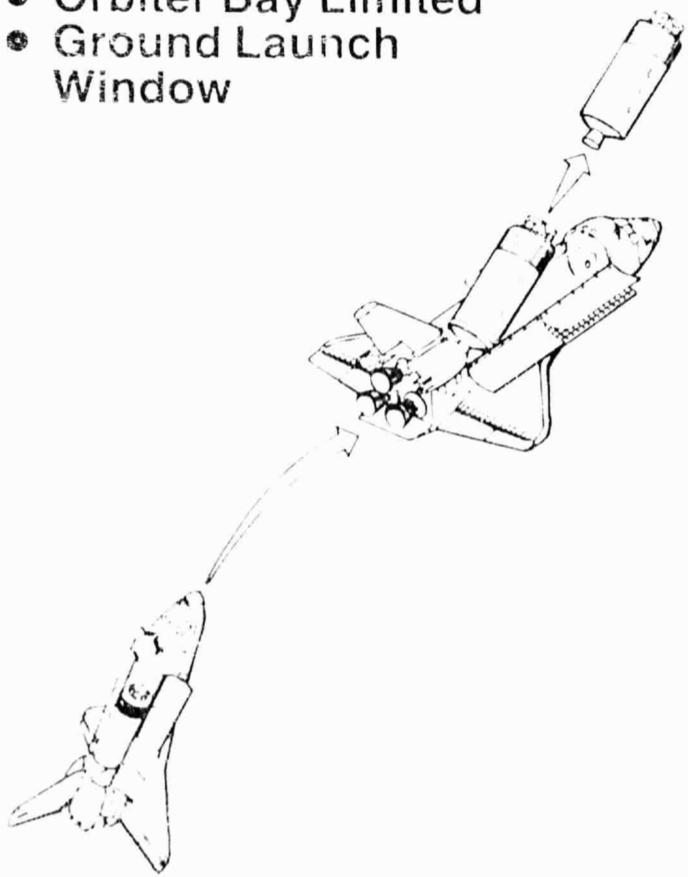
VGB645

GEOSYNCHRONOUS TRANSPORTATION

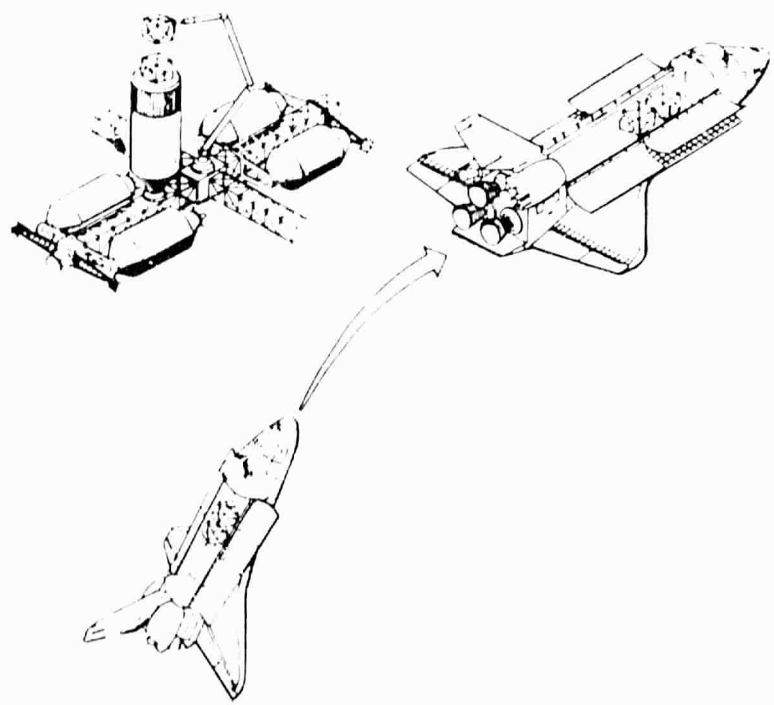
EXPENDABLE OTV

- High-Cost Stage Expended
- Orbiter Bay Limited
- Ground Launch Window



REUSABLE OTV

- Low Transportation Cost to GEO
- Utilizes ET Propellant
- Unconstrained By Orbiter
- 2-Stage ROTV Maximizes Flexibility



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DEDICATED SATELLITE MISSIONS

VGB395

Reusable OTV Candidates

ID	NAME	[illegible] PER YEAR 90	91	92	93	94	95	96	97	98	99	10 YR TOTAL 00	INC DEG	ALT KM	[illegible]
XAS012	SIMULT ASTRO EXP	1	0	0	0	0	0	0	0	0	0	1	0	GEO	[illegible]
XAS01[illegible]	FAR UV SPECT EXP	1	0	0	0	0	0	0	0	0	0	1	0	GEO	[illegible]
XCM001	INTELSAT VI	2	1	2	2	0	0	0	0	0	0	7	0	GEO	[illegible]
XCM002	INTELSAT VII	[illegible]	0	0	0	1	[illegible]	3	2	0	0	8	0	GEO	[illegible]
XCM004	TEL[illegible]	0	0	0	0	1	0	0	0	0	0	1	0	GEO	[illegible]
XCM005	WESTAR	0	0	2	1	0	0	0	0	0	0	3	0	GEO	[illegible]
XCM006	TDRS/ADV WESTAR	0	1	0	1	1	1	1	0	[illegible]	0	5	0	GEO	[illegible]
XCM007	SATCOM	0	0	1	1	1	1	0	0	0	0	4	0	GEO	895
XCM008	SBS	0	1	0	0	1	1	1	0	0	0	4	0	GEO	550
XCM009	GALAXY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XCM010	SYNCOM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XCM011	GSTAR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XCM013	STC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XCM014	DBS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XCM016	DATA TRANS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XCM017	BANKING	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XCM01[illegible]	MAIL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XCM019	SATCOL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
XCM021	TELESAT	1	0	2	0	1	0	0	1	0	0	5	0	GEO	70[illegible]
XCM022	CHICOMSAT	1	0	0	0	1	1	0	1	0	0	4	0	GEO	702
XCM023	PALAPA	0	1	0	1	0	0	1	0	0	0	3	0	GEO	[illegible]
XCM024	MISC	0	1	1	0	1	1	0	0	0	0	4	0	GEO	762
XCM025	NATO	0	0	0	0	0	1	1	0	0	0	2	0	GEO	432
XCM026	TRACK/DATA ACQUISIT	0	0	1	0	0	0	0	0	0	0	1	0	GEO	800
XES004	GEO OP ENV SAT	0	0	1	0	0	0	0	1	0	0	2	0	GEO	974
XEP001	GEOS	2	0	0	[illegible]	[illegible]	0	0	2	0	0	6	0	GEO	400
XXX002	INSAT	0	1	0	0	1	0	0	0	0	0	2	0	GEO	591

- 139 Payload Deliveries to GEO
- 27 Payload Types
- 165,000 kg Delivered
- 13/Year Average at 1200 kg Each

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OTV ANALYSIS FACTORS

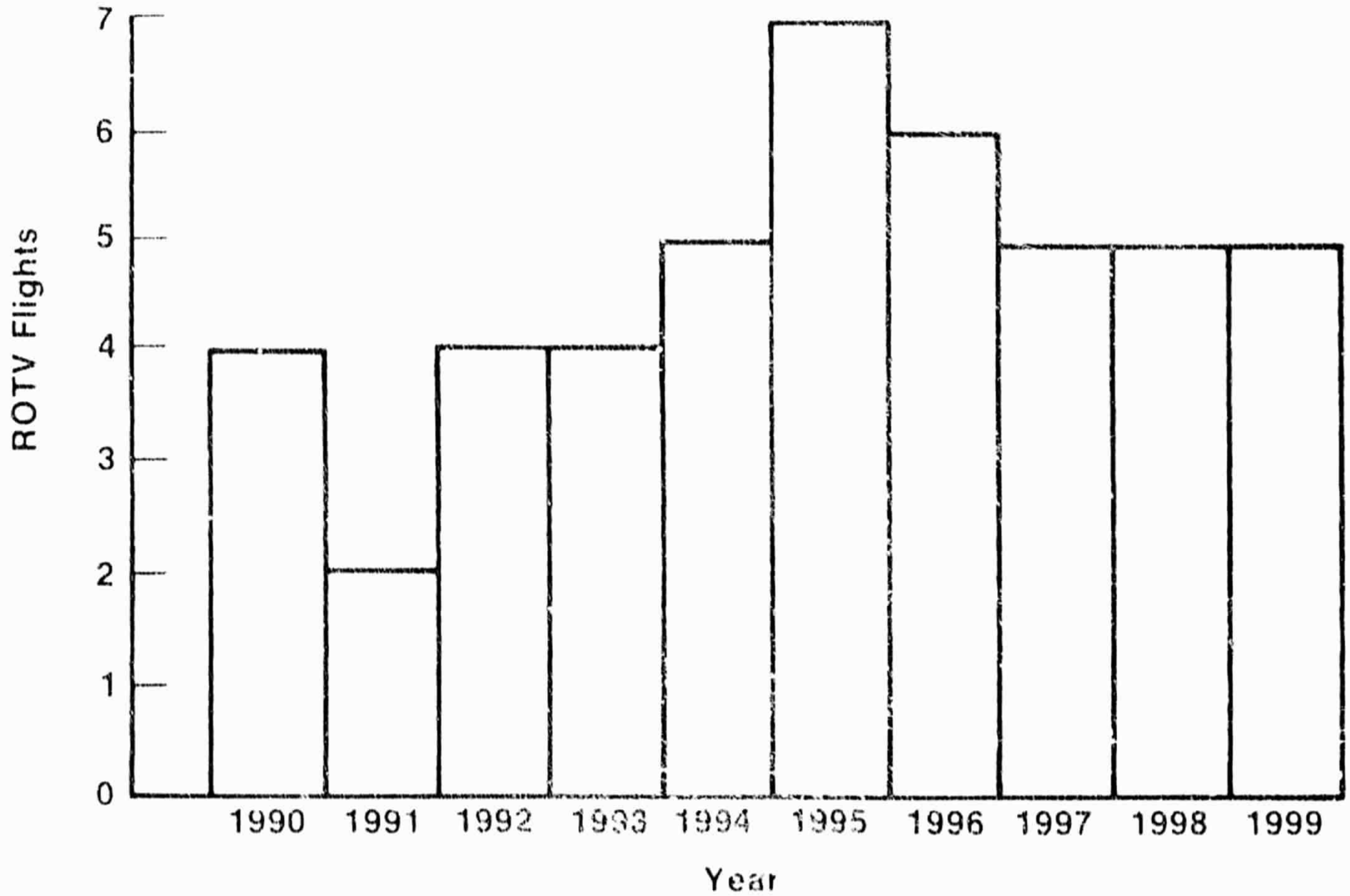
- Traffic Model
  - Outside Users
  - NASA
- OTV Concept
  - Reusable/Expendable
  - All Propulsive/Aerobraking
  - Single/Multiple Stages/Modular
- Cryogen Availability
  - Scavenging
  - Payload Top/Off
- Ancillary Elements
  - STS
  - Propellant Depot

MCDONNELL DOUGLAS

VGB644

NUMBER OF OTV FLIGHTS

4000-kg Capability, ≤ 4 Payload/Flight



MCDONNELL DOUGLAS

VGB641

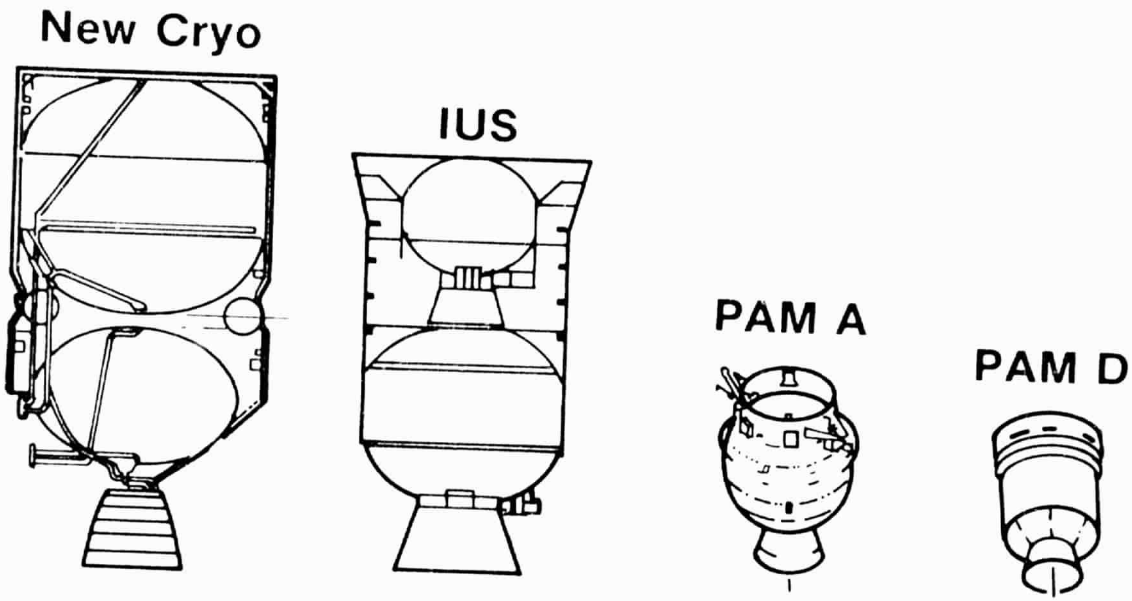
TYPICAL MANIFEST - 1995

OTV Flight Number		1	2	3	4	5	6	7
PLD (kg)	1	3636	3636	2273	632	1314	1136	702
	2			636	1314	1136	895	702
	3			550	702	432	702	636
	4				702	636		
Total (kg)		3636	3636	3459	3350	3518	2733	2040

MCDONNELL DOUGLAS

VGB642

CANDIDATE EXPENDABLE OTV



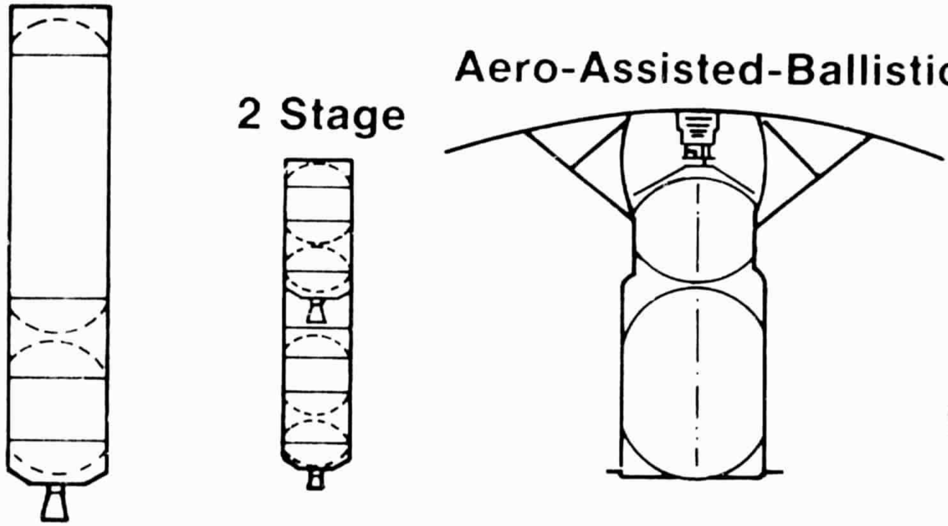
	New Cryo	IUS	PAM A	PAM D
Propellant (kg)	8770	12,454	3,500(1)	2,000(1)
Stage (kg)	9774	14,550	3860(1)	2,180(1)
ASE (kg)	3300	3,340	1,910	1,140
λ'	0.90			
Payload Into GEO (kg)	4000	2,273	1,000	636

(1) Does Not Include AKM

MCDONNELL DOUGLAS

VGB643

CANDIDATE REUSABLE OTV



	Single Stage	2 Stage	Aero-Assisted-Ballistic
Propellant (kg)	26,840	2 x 6250	15,460
λ'	0.90	0.90	0.86
GEO Delivery (kg)*	4,000	4,000	4,000
GEO Retrieval (kg)	1,448	860	4,471
GEO Round Trip (kg)	1,063	720	2,112
GEO Delivery, Expendable (kg)	12,240	6,000**	6,252

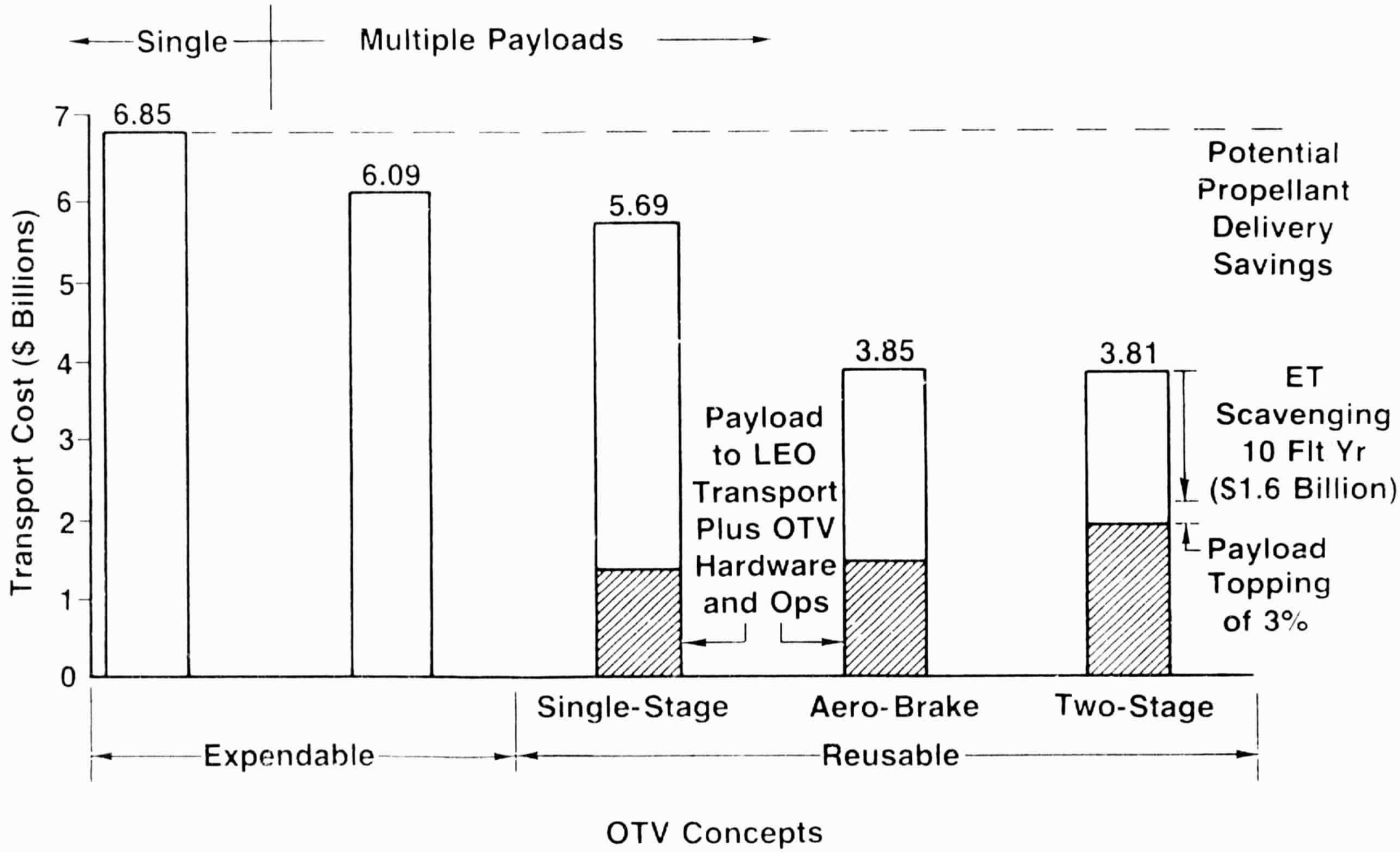
*Design Condition
**One Stage Expended

MCDONNELL DOUGLAS

GEO TRANSPORT COST COMPARISON

1990-2000 MISSION MODEL

VGB715



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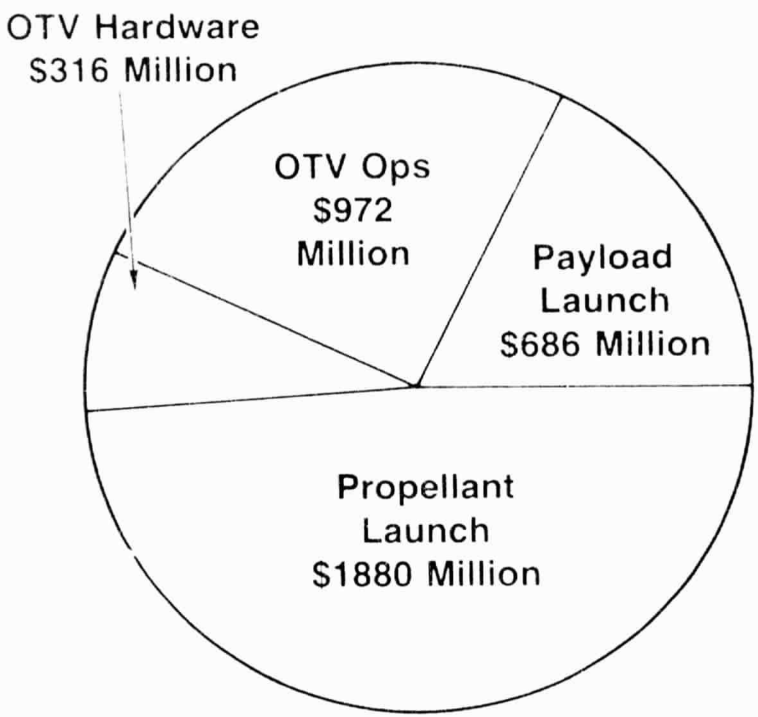
MCDONNELL DOUGLAS

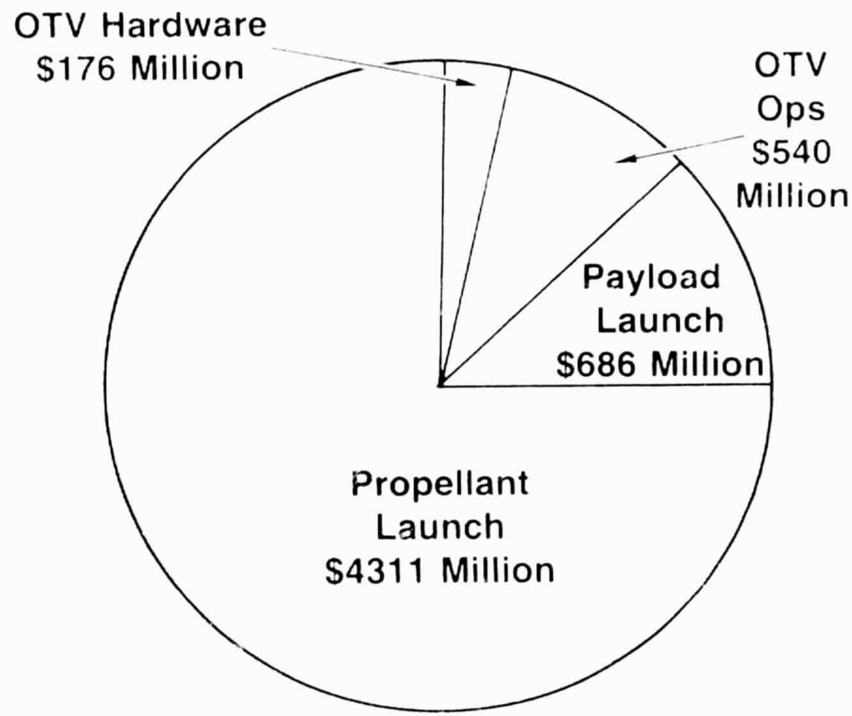
VGB716

DISTRIBUTION OF TRANSPORTATION COSTS

GEO MISSION MODEL YEAR 1990-2000



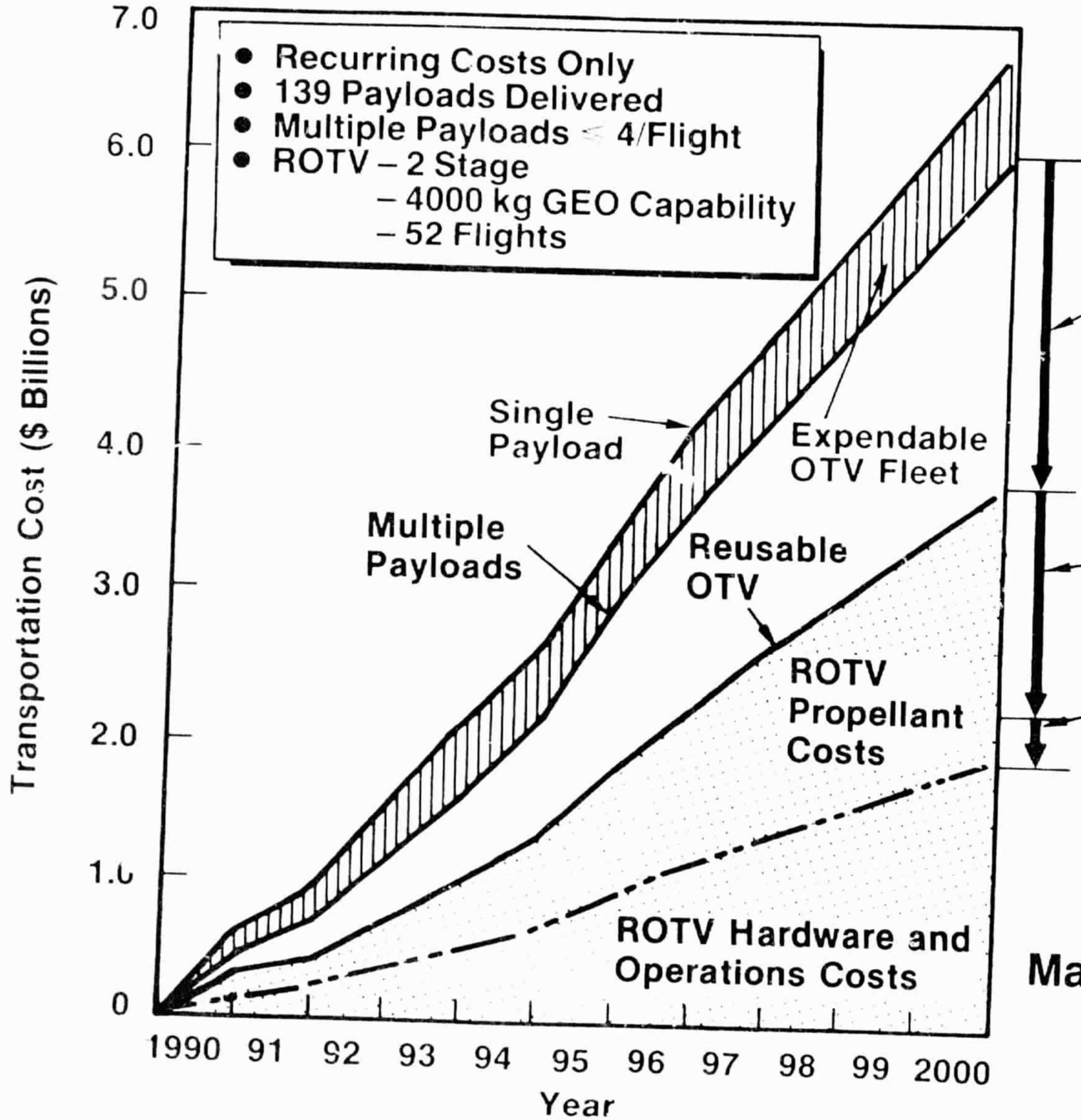
Two-Stage ROTV —
Multiple Payload
$3.8 Billion



Single-Stage ROTV —
Multiple Payload
$5.7 Billion

GEO MISSION MODEL TRANSPORT COSTS

VGB393



Savings:

2-Stage ROTV — $2.3 Billion

Scavenging — $1.6 Billion

Payload Topping — $0.3 Billion (Uses 3% of Cargo)

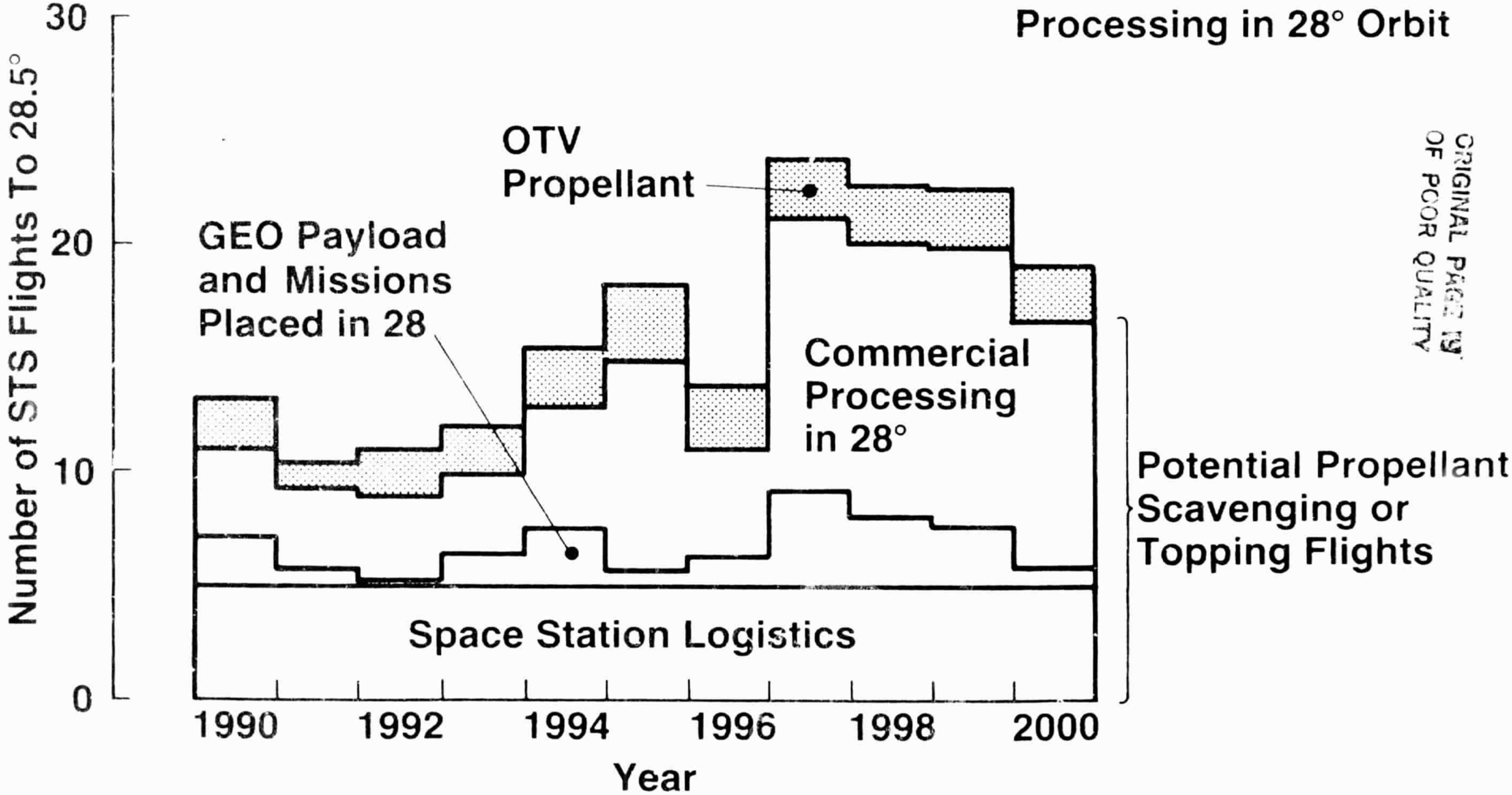
Max Savings $4.2 Billion

MCDONNELL DOUGLAS

VGB665

STS FLIGHT HISTORY SPACE STATION AT 28.5°

Note: Space Station and Commercial Material Processing in 28° Orbit



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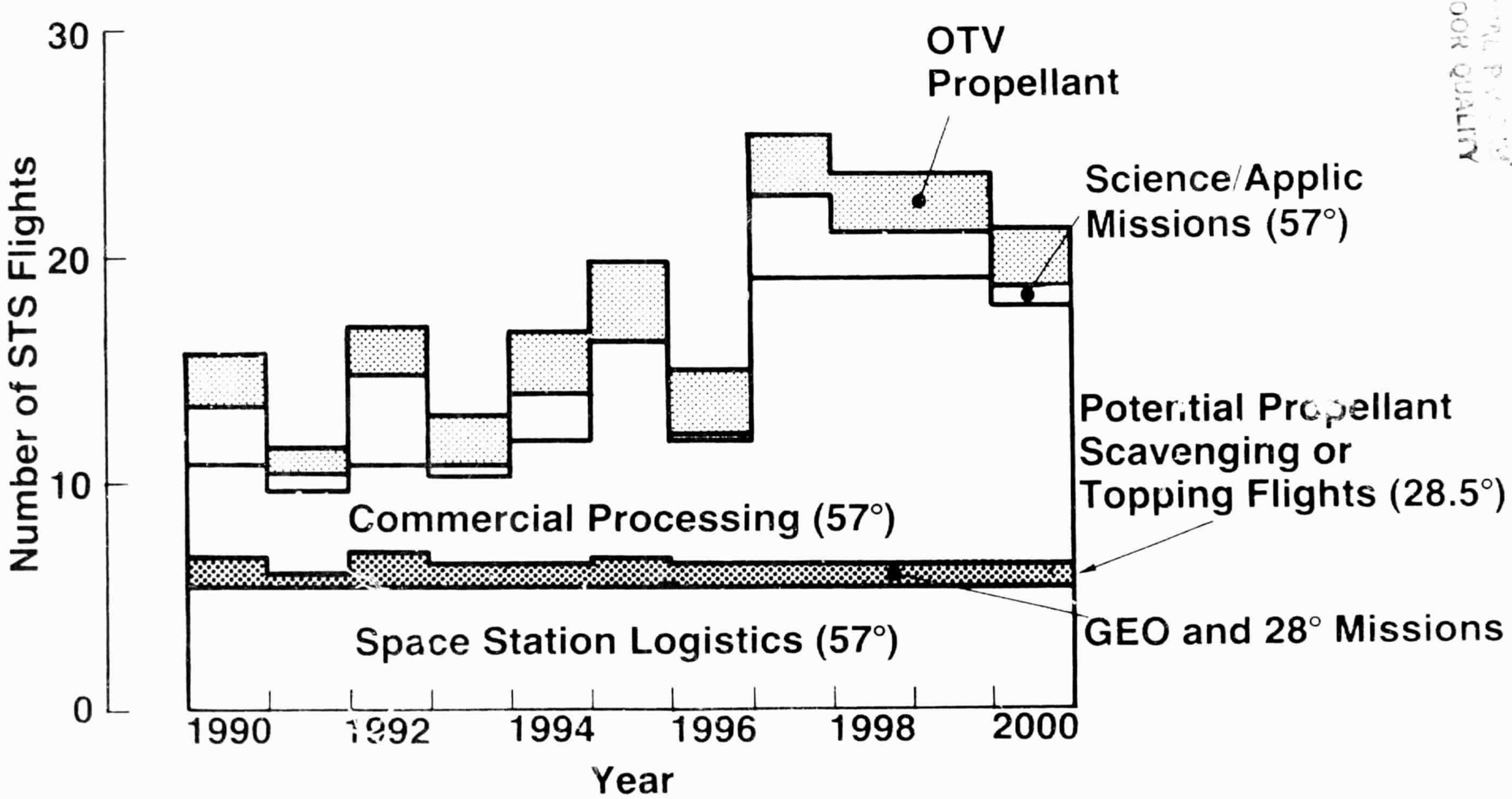
MCDONNELL DOUGLAS

VGB666

STS FLIGHT HISTORY SPACE STATION AT 57°



IMPACT OF OPERATIONS ON SPACE STATION

VG87…

ROTV (2-Stage)

■ Flights/Year	6-12
■ Propellant Usage/Year	75,000-150,000 kg
■ Turnaround Labor	200 Man-Hours
■ Electric Power	2 kW Peak
■ Communication	Hardwire and RF Link
■ Facilities	RMS, Berthing, Control Console

TMS

■ Flights/Year	6
■ Propellant Usage/Year	6,500 kg
■ Turnaround Labor	120 Man-Hours
■ Electric Power	1.3 kW Peak
■ Communication	Hardwire and RF Link
■ Facilities	RMS, Berthing, Control Console

Payload Integration

■ Number of Integrations	6-12
■ Manpower	20 Man-Hours
■ Facilities	RMS, Storage Hangar, Control Console

RESULTS/CONCLUSIONS — OPERATIONS MISSIONS

MCDONNELL DOUGLAS

VGB718

ROTV

- ROTV Can Save $4.2 Billion/10 Yr
- ROTV Development Offset
- Two-Stage ROTV Offers Flexibility
- Multiple Payloads Advantageous

- Potential Commercial Venture
- Early Technology Missions Needed
- Systems Analyses Recommended

Satellite Servicing

- Servicing of Planned High-Value Missions Would Save 2 Flights/yr
- Servicing Capability Would Allow Additional Missions (Replenishment, Random Failures, etc.)

Assembly/Contstruction

- Allows Deployment of Desired Large Systems
- Technology and Economics Analyses Needed

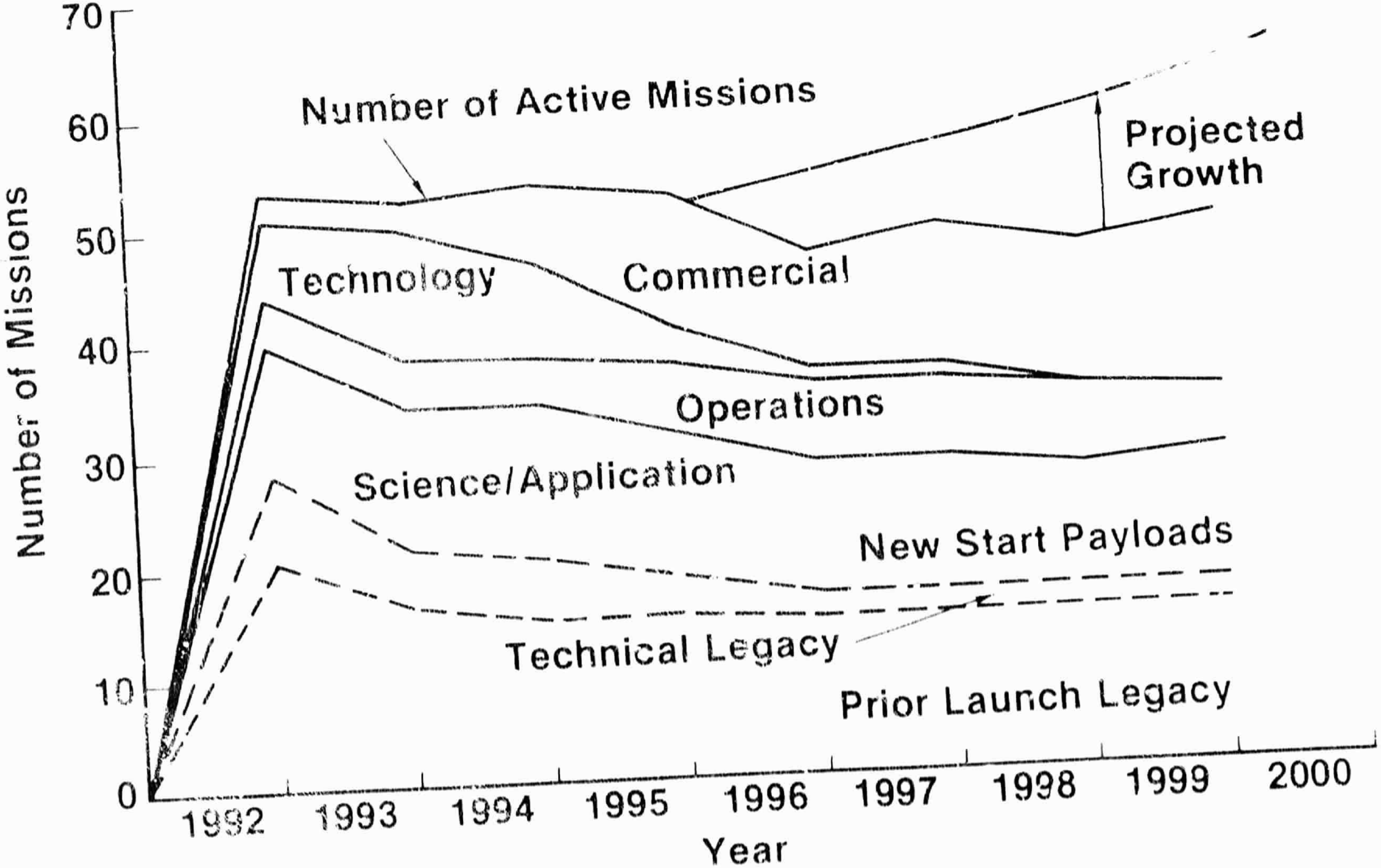
Space Station Requirements

- 28.5-deg Orbit
- Two TMS Ports
- Satellite Service Port
- ROTV Port/Service
- ROTV Control Center
- Propellant Depot
- Construction Space/Fixtures

VGB547

McDONNELL DOUGLAS

MISSION ACTIVITY



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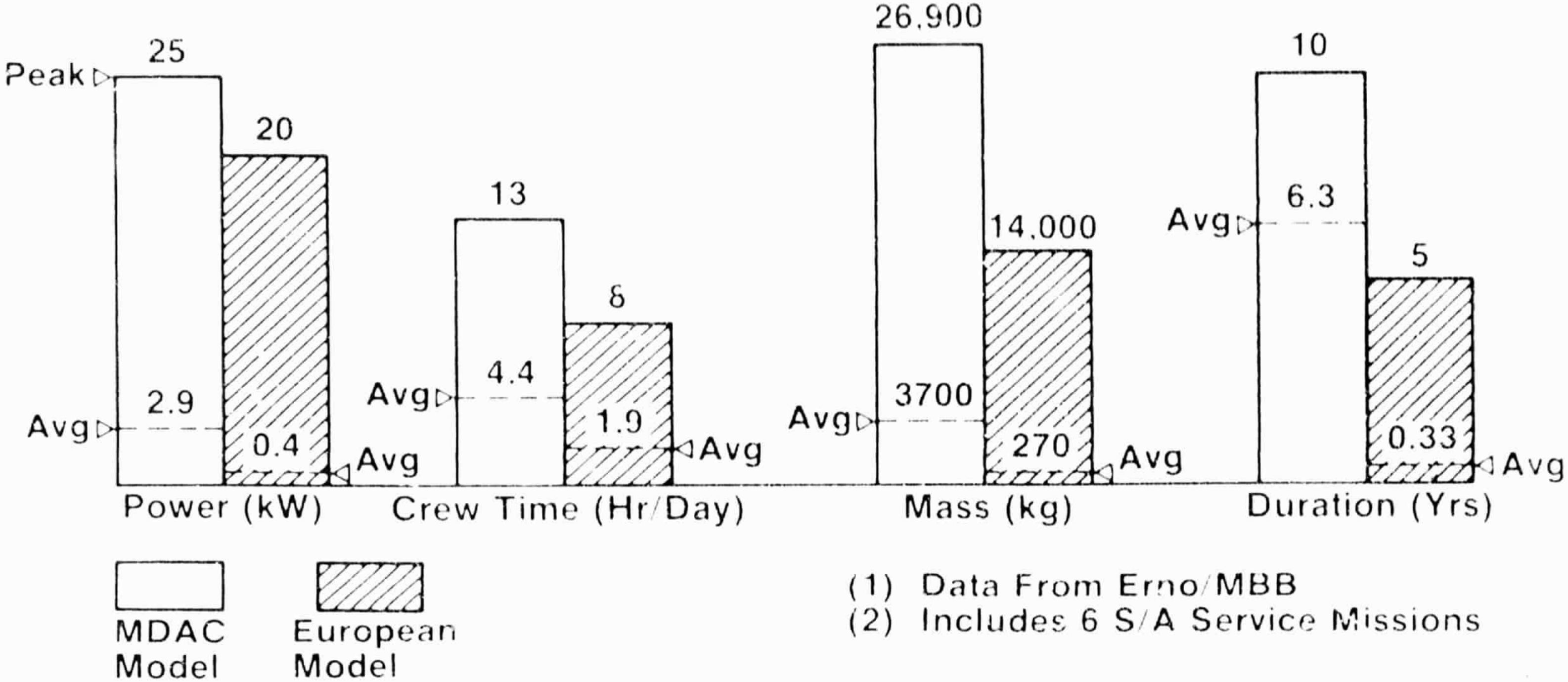
VGB810

EUROPEAN MISSIONS

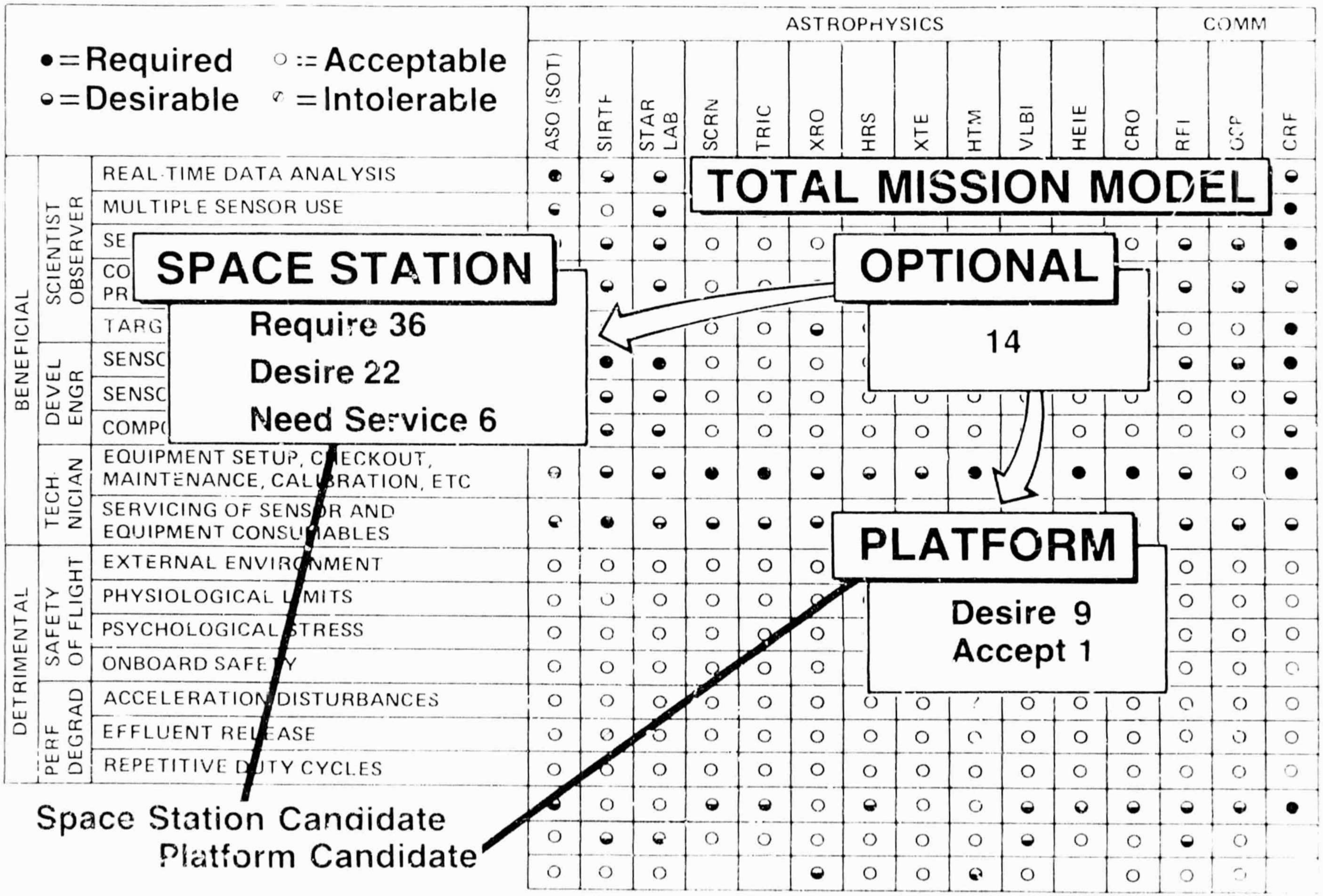
MDAC Mission Model		European Mission Model (1)	
88 Missions		104 Missions	
Science and Application	57	Science and Application	89
Operations	10(2)	Operations	4
Technology	14	Commercial Technology	11
Commercial	13		



(1) Data From Erno/MBB
(2) Includes 6 S/A Service Missions

EVALUATION OF MAN IN-ORBIT INFLUENCES

VGB813



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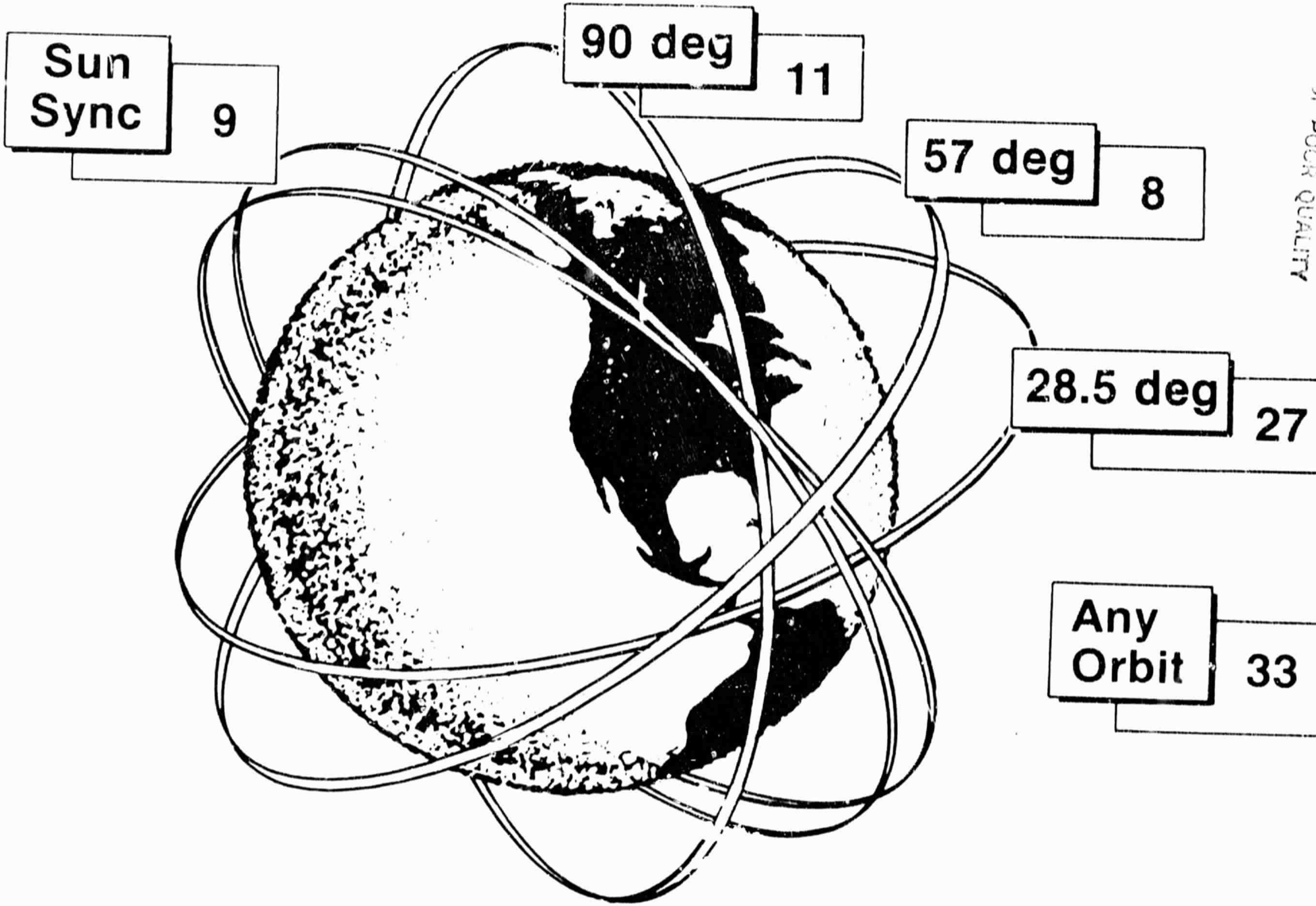
ORBIT REQUIREMENTS — ALL MISSIONS

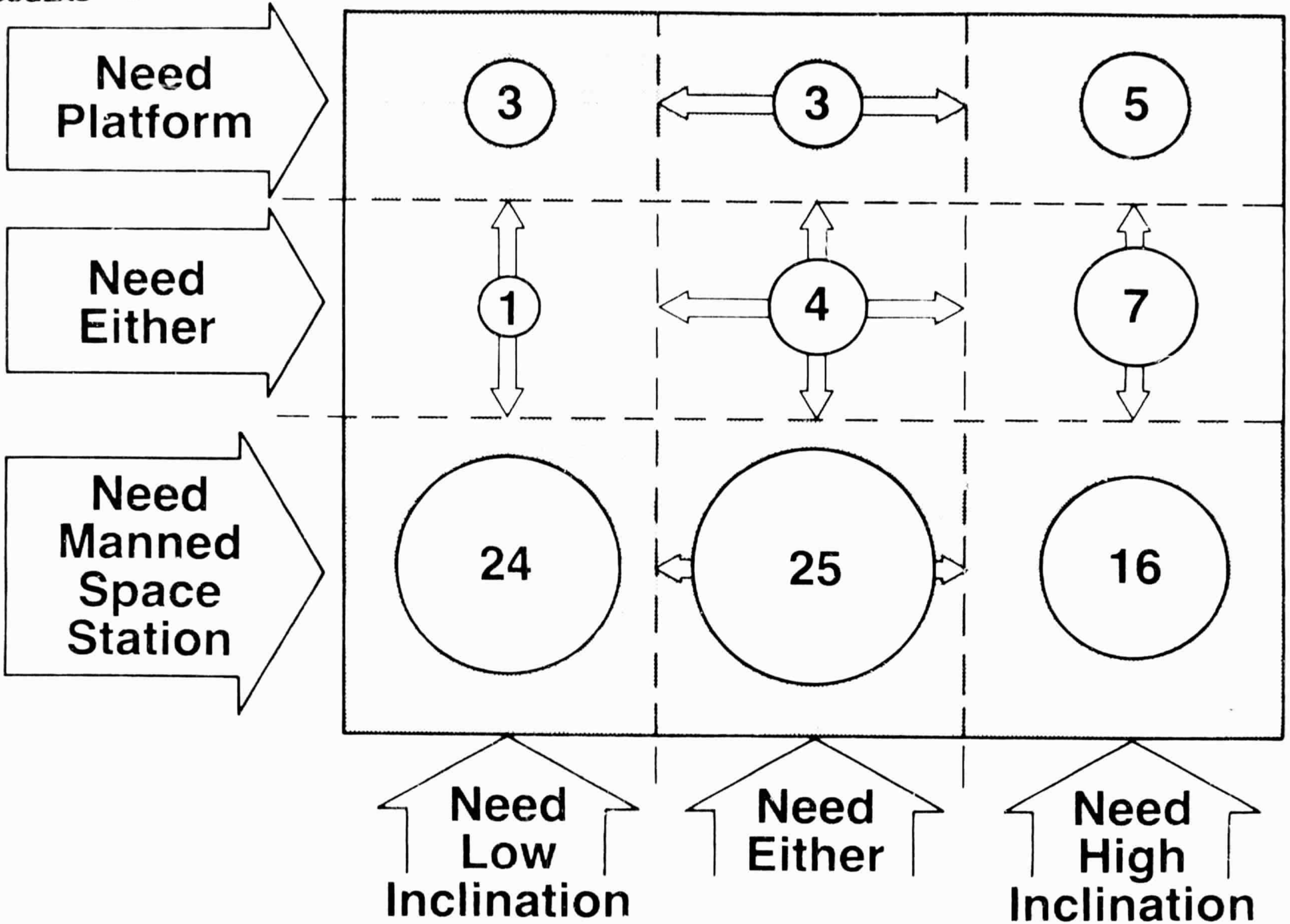
VGB662



MISSION ACCOMMODATION REQUIREMENTS
88 MISSIONS TOTAL

MCDONNELL DOUGLAS

VGB667



MCDONNELL DOUGLAS

VGB825

BENEFITS AND PRIORITIZATION ANALYSES

• SOCIAL • ECONOMIC • CULTURAL • SCIENTIFIC
• TECHNOLOGICAL • COMMERCIAL

34 FACTORS EVALUATED

- Population Affected: U.S., World
- Value Added by Space
- International Appeal
- Cost
- Commercial Value
- Resources Required
- Scientific Value

- Identified Constituency
- Availability

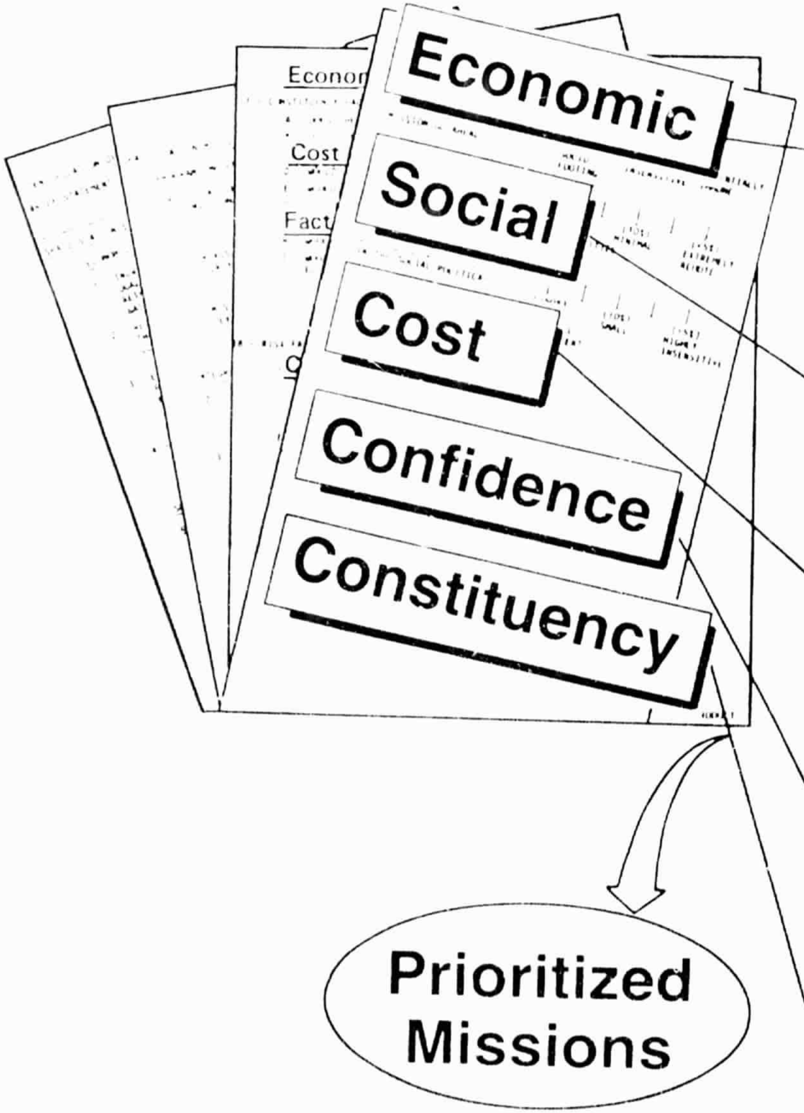
All Missions Analyzed
- 88 Missions
- 12 Evaluators
- 19,652 Value Judgements

Prioritized Missions

MCDONNELL DOUGLAS

VGB816

BENEFITS/PRIORITIZATION ANALYSIS



ECONOMIC FACTORS TO BE ASSESSED:

1 - INCREASED QUANTITY AND/OR QUALITY OF DATA OR PRODUCT RETURNED AS COMPARED TO GROUND-BASED ACTIVITY — x1 | x10 | x100

2 - REDUCTION IN STS FLIGHTS OVER THE LIFESPAN OF THE MISSION COMPARED TO OTHER APPROACHES — 0 | 2 | >5

SOCIAL FACTORS TO BE ASSESSED:

5 - DEMOGRAPHIC IMPACT ON U.S. POPULATION - 1990 - 2000 (≈ 240 MILLION) — <5% | 25% | >50%
POPULATION AFFECTED

PROGRAM IMPLEMENTATION FACTORS:

9 - TOTAL INITIAL OUTLAY FOR MISSION/PAYLOAD EQUIPMENT — >100 $MIL | 10 $MIL | <1 $MIL

RISK FACTORS TO BE CONSIDERED:

A - TECHNICAL DEVELOPMENT UNCERTAINTY IN MEETING OPERATION REQUIREMENTS OF THE MISSION — BREAKTHRU REQUIRED | APPLICATION OF EXISTING TECHNOLOGY | SIMILAR SYSTEMS ARE OPERATIONAL

CONSTITUENCY FACTORS TO BE CONSIDERED:

A - DOES THE MISSION HAVE BASIC INTRINSIC APPEAL? Y N

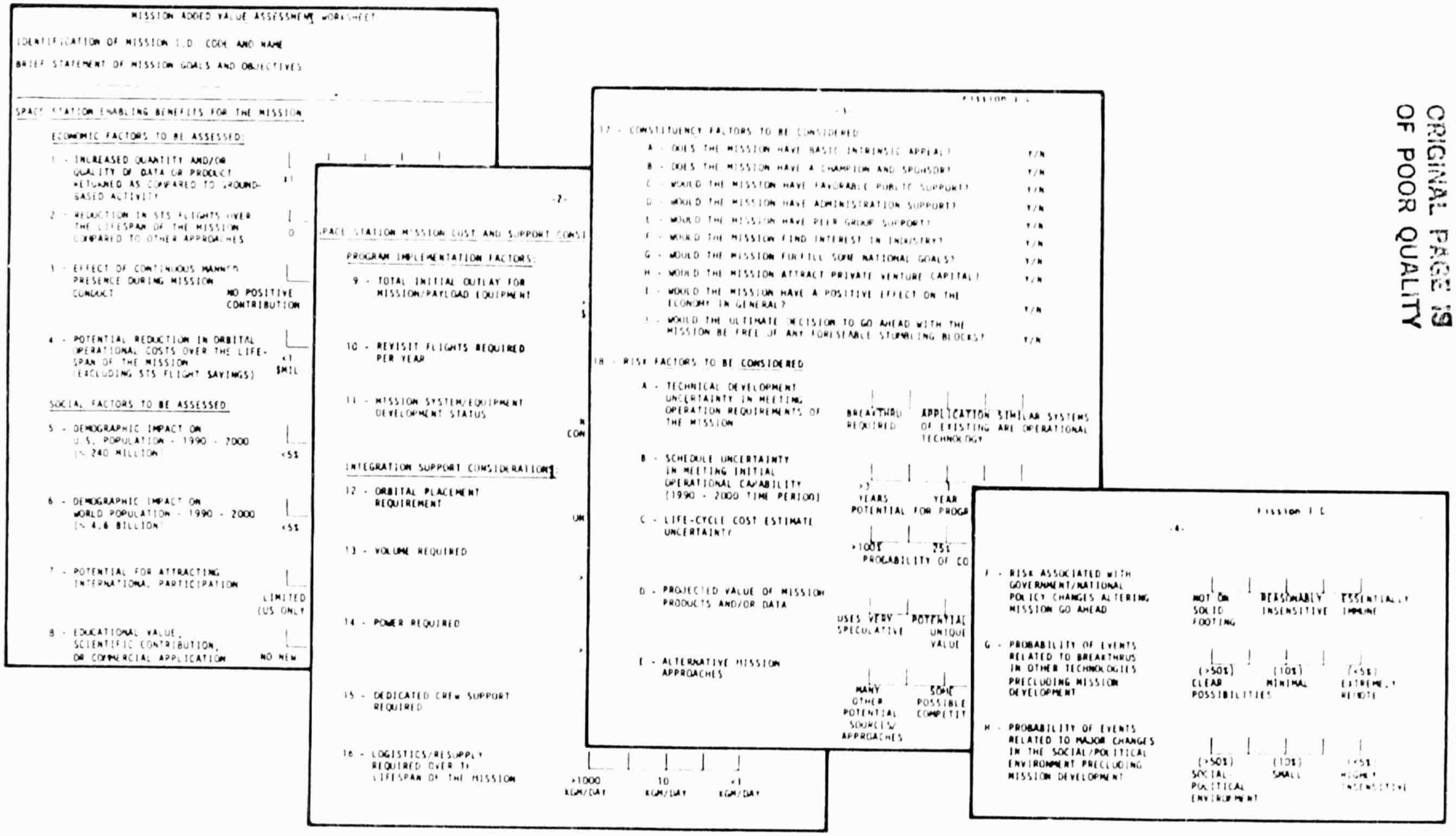
B - DOES THE MISSION HAVE A CHAMPION AND SPONSOR? Y N

C - WOULD THE MISSION HAVE FAVORABLE PUBLIC SUPPORT? Y N

MCDONNELL DOUGLAS

VGB721

BENEFITS ANALYSIS PARAMETERS


MISSION ADDED VALUE ASSESSMENT WORKSHEET

IDENTIFICATION OF MISSION I.D. CODE AND NAME

BRIEF STATEMENT OF MISSION GOALS AND OBJECTIVES

SPACE STATION ENABLING BENEFITS FOR THE MISSION

ECONOMIC FACTORS TO BE ASSESSED

1 - INCREASED QUANTITY AND/OR QUALITY OF DATA OR PRODUCT RETURNED AS COMPARED TO GROUND-BASED ACTIVITY

2 - REDUCTION IN STS FLIGHTS OVER THE LIFESPAN OF THE MISSION COMPARED TO OTHER APPROACHES

3 - EFFECT OF CONTINUOUS MANNED PRESENCE DURING MISSION CONDUCT — NO POSITIVE CONTRIBUTION

4 - POTENTIAL REDUCTION IN ORBITAL OPERATIONAL COSTS OVER THE LIFE-SPAN OF THE MISSION (EXCLUDING STS FLIGHT SAVINGS) — <1 $MIL

SOCIAL FACTORS TO BE ASSESSED

5 - DEMOGRAPHIC IMPACT ON U.S. POPULATION - 1990 - 2000 (≈ 240 MILLION) — <5%

6 - DEMOGRAPHIC IMPACT ON WORLD POPULATION - 1990 - 2000 (≈ 4.6 BILLION) — <5%

7 - POTENTIAL FOR ATTRACTING INTERNATIONAL PARTICIPATION — LIMITED (US ONLY)

8 - EDUCATIONAL VALUE, SCIENTIFIC CONTRIBUTION, OR COMMERCIAL APPLICATION — NO NEW

-2-

SPACE STATION MISSION COST AND SUPPORT CONSI...

PROGRAM IMPLEMENTATION FACTORS

9 - TOTAL INITIAL OUTLAY FOR MISSION/PAYLOAD EQUIPMENT

10 - REVISIT FLIGHTS REQUIRED PER YEAR

11 - MISSION SYSTEM/EQUIPMENT DEVELOPMENT STATUS

INTEGRATION SUPPORT CONSIDERATIONS

12 - ORBITAL PLACEMENT REQUIREMENT

13 - VOLUME REQUIRED

14 - POWER REQUIRED

15 - DEDICATED CREW SUPPORT REQUIRED

16 - LOGISTICS/RESUPPLY REQUIRED OVER THE LIFESPAN OF THE MISSION — >1000 KGM/DAY — 10 KGM/DAY — <1 KGM/DAY

-3-

MISSION I.D.

17 - CONSTITUENCY FACTORS TO BE CONSIDERED

A - DOES THE MISSION HAVE BASIC INTRINSIC APPEAL? Y/N

B - DOES THE MISSION HAVE A CHAMPION AND SPONSOR? Y/N

C - WOULD THE MISSION HAVE FAVORABLE PUBLIC SUPPORT? Y/N

D - WOULD THE MISSION HAVE ADMINISTRATION SUPPORT? Y/N

E - WOULD THE MISSION HAVE PEER GROUP SUPPORT? Y/N

F - WOULD THE MISSION FIND INTEREST IN INDUSTRY? Y/N

G - WOULD THE MISSION FULFILL SOME NATIONAL GOALS? Y/N

H - WOULD THE MISSION ATTRACT PRIVATE VENTURE CAPITAL? Y/N

I - WOULD THE MISSION HAVE A POSITIVE EFFECT ON THE ECONOMY IN GENERAL? Y/N

J - WOULD THE ULTIMATE DECISION TO GO AHEAD WITH THE MISSION BE FREE OF ANY FORESEEABLE STUMBLING BLOCKS? Y/N

18 - RISK FACTORS TO BE CONSIDERED

A - TECHNICAL DEVELOPMENT UNCERTAINTY IN MEETING OPERATION REQUIREMENTS OF THE MISSION — BREAKTHRU REQUIRED — APPLICATION OF EXISTING TECHNOLOGY — SIMILAR SYSTEMS ARE OPERATIONAL

B - SCHEDULE UNCERTAINTY IN MEETING INITIAL OPERATIONAL CAPABILITY (1990 - 2000 TIME PERIOD) — >3 YEARS — YEAR — POTENTIAL FOR PROGR...

C - LIFE-CYCLE COST ESTIMATE UNCERTAINTY — >100% — 25% — PROBABILITY OF CO...

D - PROJECTED VALUE OF MISSION PRODUCTS AND/OR DATA — USES VERY SPECULATIVE — POTENTIAL UNIQUE VALUE

E - ALTERNATIVE MISSION APPROACHES — MANY OTHER POTENTIAL SOURCES/APPROACHES — SOME POSSIBLE COMPETIT...

-4-

MISSION I.D.

F - RISK ASSOCIATED WITH GOVERNMENT/NATIONAL POLICY CHANGES ALTERING MISSION GO AHEAD — NOT ON SOLID FOOTING — REASONABLY INSENSITIVE — ESSENTIALLY IMMUNE

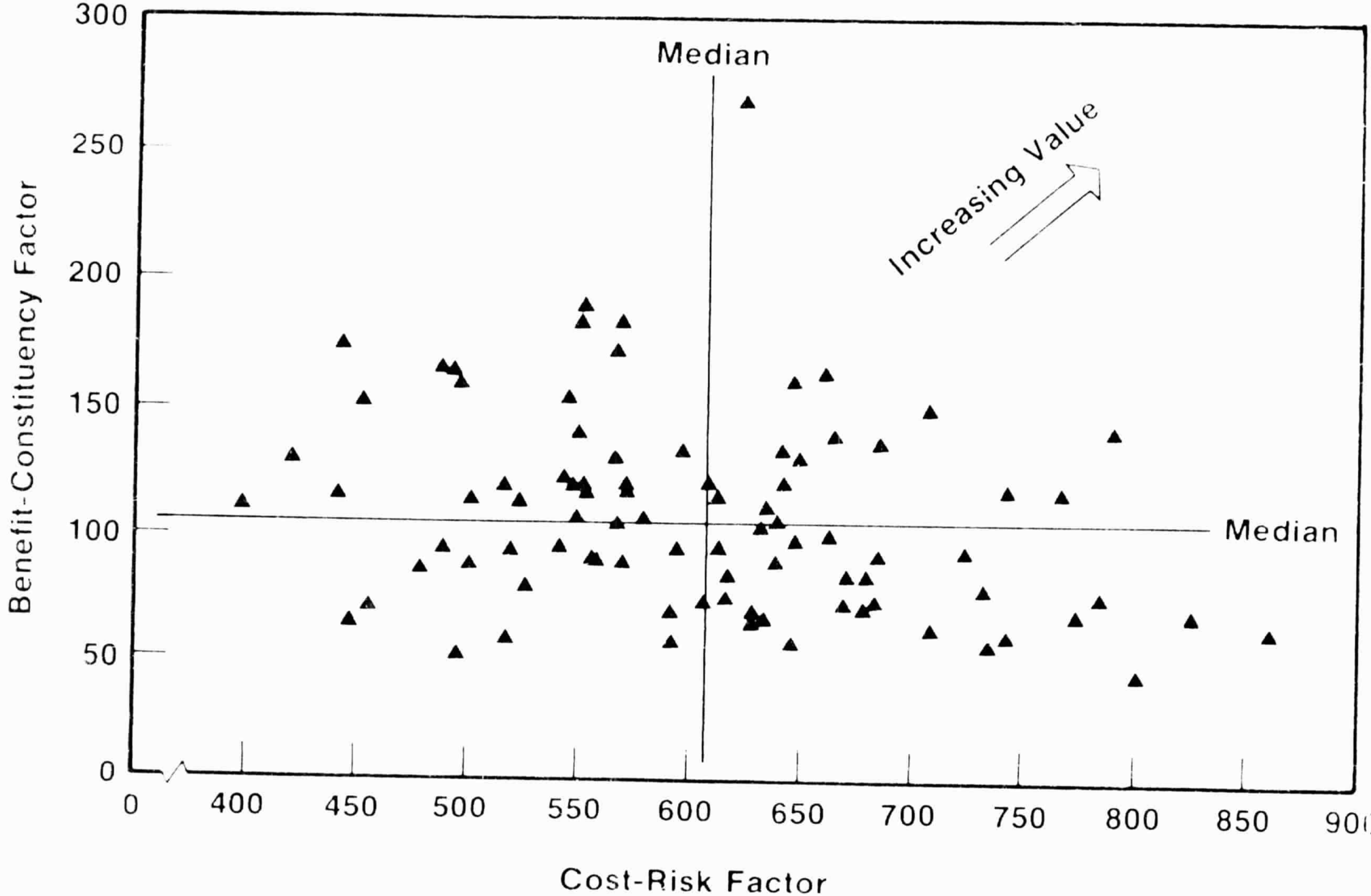
G - PROBABILITY OF EVENTS RELATED TO BREAKTHRUS IN OTHER TECHNOLOGIES PRECLUDING MISSION DEVELOPMENT — (>50%) CLEAR POSSIBILITIES — (10%) MINIMAL — (<5%) EXTREMELY REMOTE

H - PROBABILITY OF EVENTS RELATED TO MAJOR CHANGES IN THE SOCIAL/POLITICAL ENVIRONMENT PRECLUDING MISSION DEVELOPMENT — (>50%) SOCIAL POLITICAL ENVIRONMENT — (10%) SMALL — (<5%) HIGHLY INSENSITIVE

MCDONNELL DOUGLAS

VGB640

MISSION VALUE DISTRIBUTION



MCDONNELL DOUGLAS

PRIORITIZED MISSION MODEL

VGB558

GROUP 1 20 MISSIONS

- CMP001 ELECTROPHORETIC PRO
- CMP009 TOXIC WASTE MONITOR
- OSR001 SAT SERV OPS
- OTR001 TMS OPS
- SAS001 ADV SOL OBS(ASO/SOT)
- SAS009 SPACE TELESC
- SAS011 XRAY TIMING EXPL
- SAS013 ADV XRAY ASTROFAC
- SEP001 SAR
- SEP002 MULTISPECT LIN ARRAY
- SEP004 PASS MICROWAVE RAD
- SEP005 LARGE FORMAT CAMERA
- SEP009 LANDSAT D-D'
- SEP010 RADAR ALT
- SMP003 MATERIALS EXP ASS
- TGN005 LRG STRUCT CONSTR
- TGN006 FLUID STORE&MANAG
- TOP001 SATELL SERV TECH
- TOP002 OTV SERVICE TECH
- TOP004 MAN ROLE EVAL

GROUP 2 23 MISSIONS

- CIR001 MATERIALS RES FAC
- OTR004 OTV OPS (2STG)
- SAS002 SIRTF
- SAS003 STARLAB
- SAS004 COMP SPEC COSRAY NUC
- SAS015 VLBI
- SAS017 GAMMA RAY OBS
- SAS020 COSMIC RAY OBS
- SCM002 ORB STANDARDS PACK
- SEE001 OCEAN PAYLOAD
- SEE003 UPPER ATMOS RES
- SEE004 SPACE PLASMA PHYSICS
- SEE007 ATM DYNAMICS&RAD
- SEE008 OP CIVIL MET
- SEP006 IMAGE SPECTROMETER
- SLS001 PRIMATE EXP FAC
- SLS002 PLANT BIO/LS FACIL
- SLS003 RODENT EXP FACIL
- SLS006 HUMAN EXP FAC
- SMP001 MATERIALS PROC LAB
- SMP002 MATERIALS EXP CARR
- TGN002 ZERO G ANT RANGE
- TGN009 ELCS OXY REC

GROUP 3 21 MISSIONS

- CMP003 ELECTRONIC CIR ELEM
- CMP006 DIR XTAL GROWTH
- CMP010 BIO PROCESSING
- OAI001 STRUCT ASSY & TEST
- SAS007 TRANS RAD ION.CAL.
- SAS008 XRAY OBSER
- SAS012 SOLAR INT DYNAMICS
- SAS014 LAMAR(HTM)
- SAS016 LRG DELP REFL
- SAS018 HIGH ENER ISO EXP
- SAS019 SOLAR COR DYN
- SEE002 ATMOS COMP
- SEE005 ZERO G CLOUD PHYSICS
- SEE006 MET. RES. PKG
- SEP007 LUMINESCENCE DET
- SEP008 LASER RANGING
- SEP012 PLAN SPECT TELE
- SEP013 IR SPECT
- TGN001 LSS CONTR EXP
- TGN004 TETHER DYNAMICS
- TOP003 CREW/MANIP CONT

GROUP 4 24 MISSIONS

- CMP002 SILICON RIBBON MAN
- CMP004 MATERIAL MELT/REFORM
- CMP005 ORIENTED MIXTURES
- CMP007 HI STRENGTH PLASTICS
- CMP008 SEPARATIONS LAB
- CMP011 MEDICAL FACILITY
- CMP012 GA AS FACILITY
- SAS006 EX LG LONG DUR EXP
- SAS010 HIRES X&G-RAY SPEC
- SCM001 REMOTE SENSING RFI
- SCM003 COMM RESEARCH FAC
- SEP003 MAG FIELD MAPPER
- SEP011 ACT FLUOR SPECT
- SEP014 FAR IR SPECT
- SEP015 EXTRA SS DET
- SEP016 PLANETARY PROC LAB
- SLS004 ORB QUARANTINE
- SLS005 EXP MED TREAT FAC
- SMP004 WAKE SHIELD EXP
- SMP005 ULTRAVACUUM FAC
- TFM001 LASER COMM&TRACK DEV
- TGN003 MATERIALS&COAT TECH
- TGN007 LIQUID DROPLET RAD
- TGN008 ECLS WATER REC

INCLUDES HIGH VALUE MISSIONS

- Commercial Processing
- Satellite Servicing (TMS)
- ROTV Enabling Technology
- Science and Applications (SAR, Xray, SOT, etc.)

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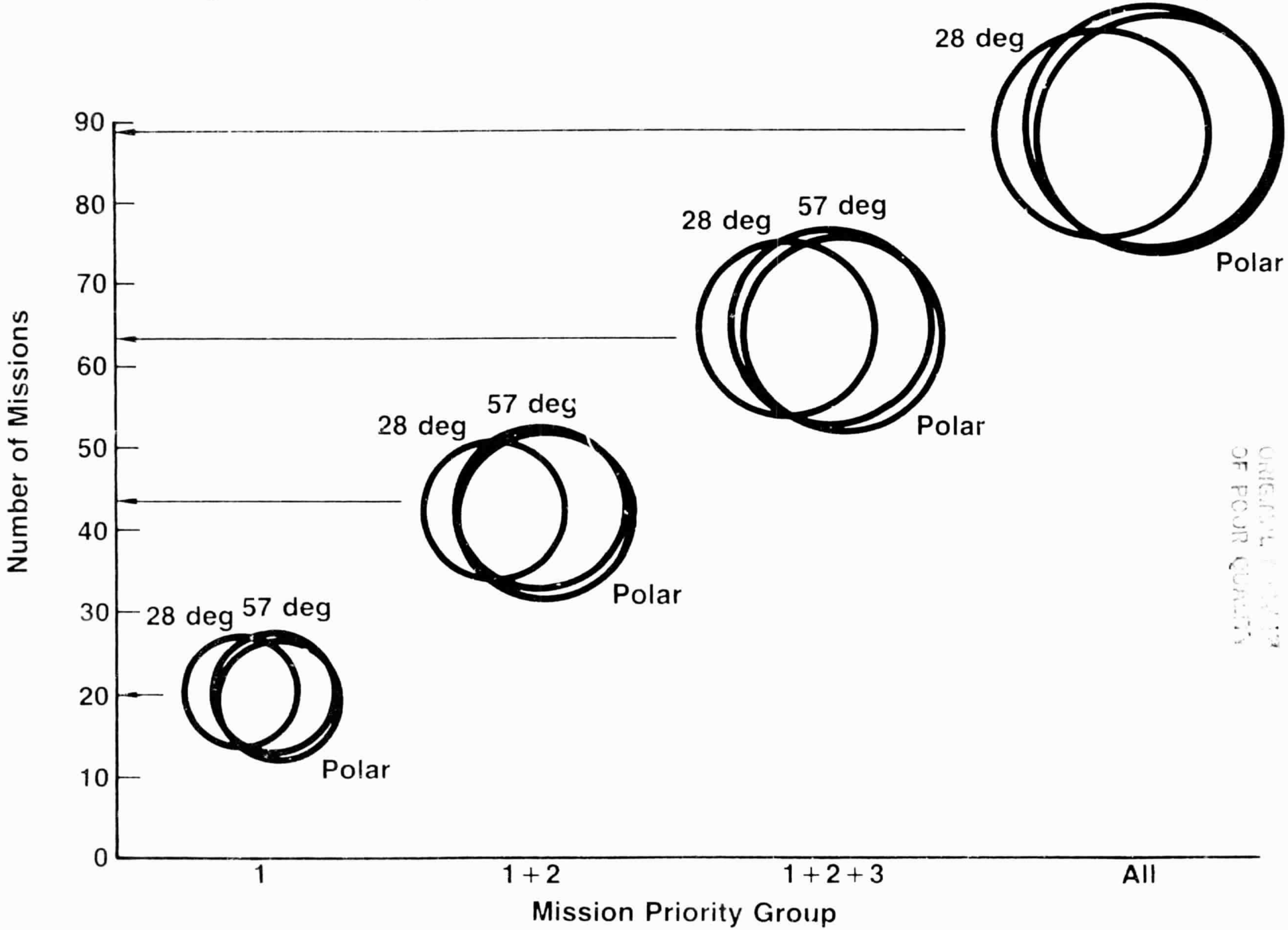
VGB719

ORBIT INCLINATION REQUIREMENTS



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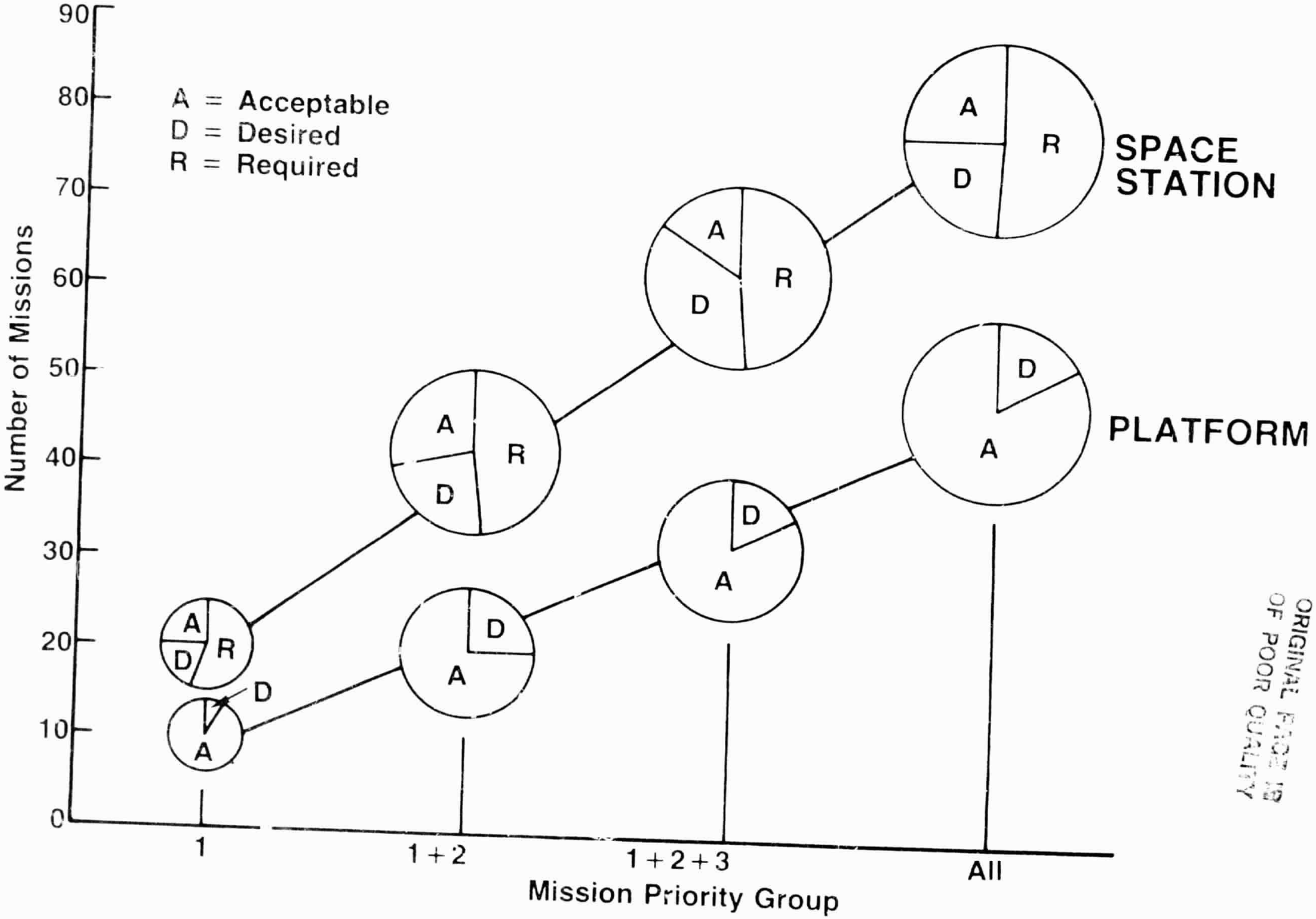
MISSION FACILITY REQUIREMENTS

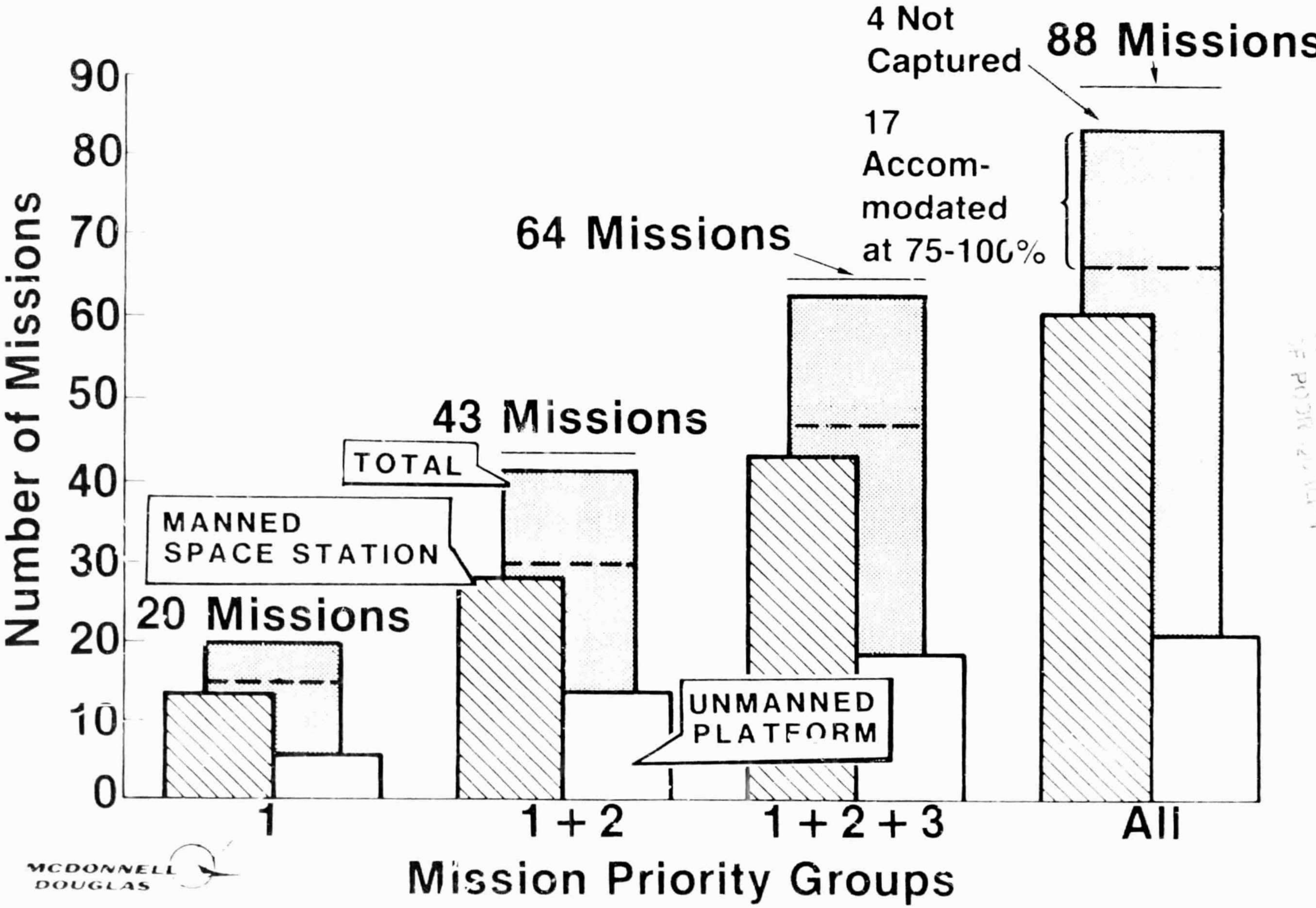
VGB720



MISSION CAPTURE BY PRIORITY GROUP

VGB391

Space Station at 28.5 deg. Platform at High Inclination



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MCDONNELL DOUGLAS

MISSION ACCOMMODATION

Prioritized Mission Model (88 Missions)

VGB664

Architecture		Missions Accommodated		Total Missions Captured
Space Station	Platform	100%	75%-100%	
28.5°	—	54	10	64
28.5°	57°	57	26	83
	90° or Sun Sync	67	17	84
57°	28.5°	60	18	78
	90° or Sun Sync	65	10	75

95%

MCDONNELL DOUGLAS

UNIQUE MISSION ACCOMMODATION SPACE STATION-28°, PLATFORM-SUN SYNC

VGB668

MISSION	PREFERENCE		INTERIM ACCOMMODATION
④			
SEM014 FAR IR SPECT	P	28.5	Dedicated Satellite
SAL006 EL LG LONG DUR EXP	SS	57	
SAS015 VLBI	E	57	
SEE003 UPPER ATMOS RES	E	57	
②			
SAS001 ADV SOL OBS(ASO SOT)	SS	97	Space Station at 28.5°
SAS003 STARLAB	P	28.5	
⑥			
TGM003 MATERIALS&COAT TECH	P	28.5	
SCM002 ORB STANDARDS PACK	SS	57	
SCM003 COMM RESEARCH FAC	SS	57	Platform at Sun Sync
SEE006 MET. RES. PKG	SS	57	
SEP005 LARGE FORMAT CAMERA	SS	90	
SEE001 OCEAN PAYLOAD	SS	97	
⑨			
CMP009 TOXIC WASTE MONITOR	SS	90	
SAS018 HIGH ENER ISO EXP	SS	57	
SAS020 COSMIC RAY OBS	SS	57	
SEE002 ATMOS COMP	SS	90	
SEE007 ATM DYNAMICS&RAD	SS	90	
SEP008 LASER RANGING	SS	90	
SEP010 RADAR ALT	SS	90	
SEP011 ACT FLUOR SPECT	SS	90	
SEP002 MULTISPECT LIN ARRAY	SS	97	

P — Platform
SS — Space Station
E — Either

Growth Accommodations

- Platform 28.5°
  - Manned Station-Polar
    - Platform 57°

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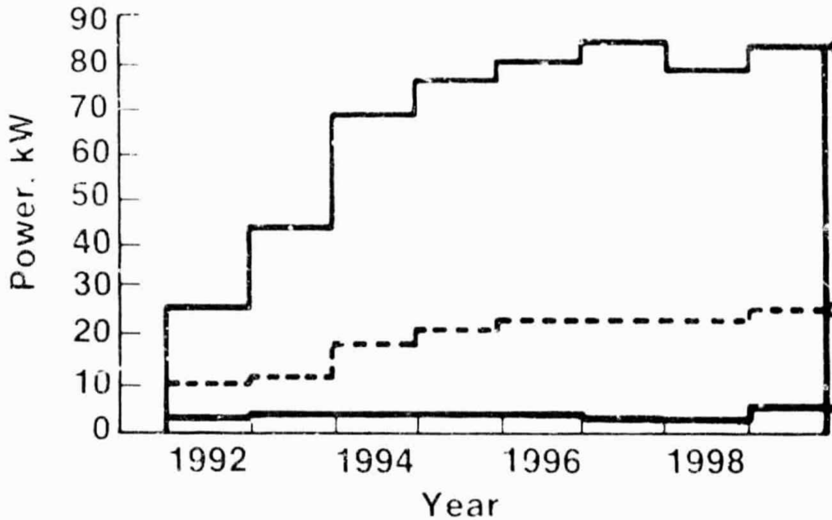
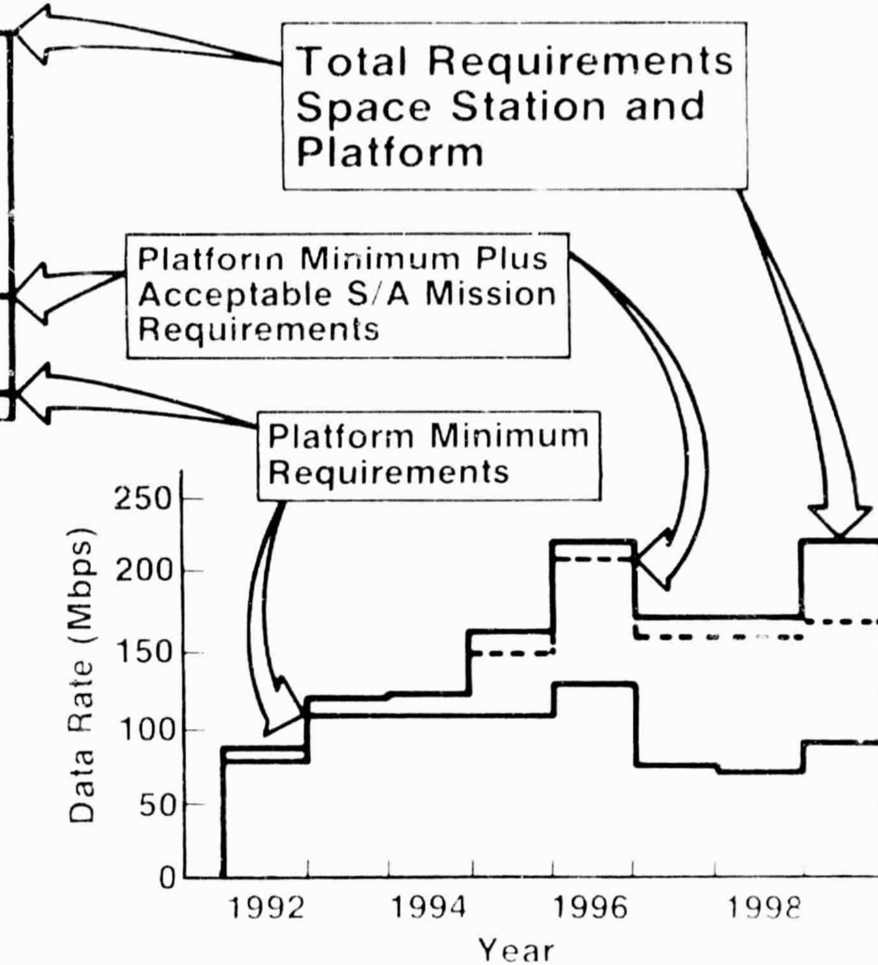
TOTAL MISSION REQUIREMENTS

VGB767

STATION AT 28.5°, PLATFORM AT SUN SYNCHRONOUS



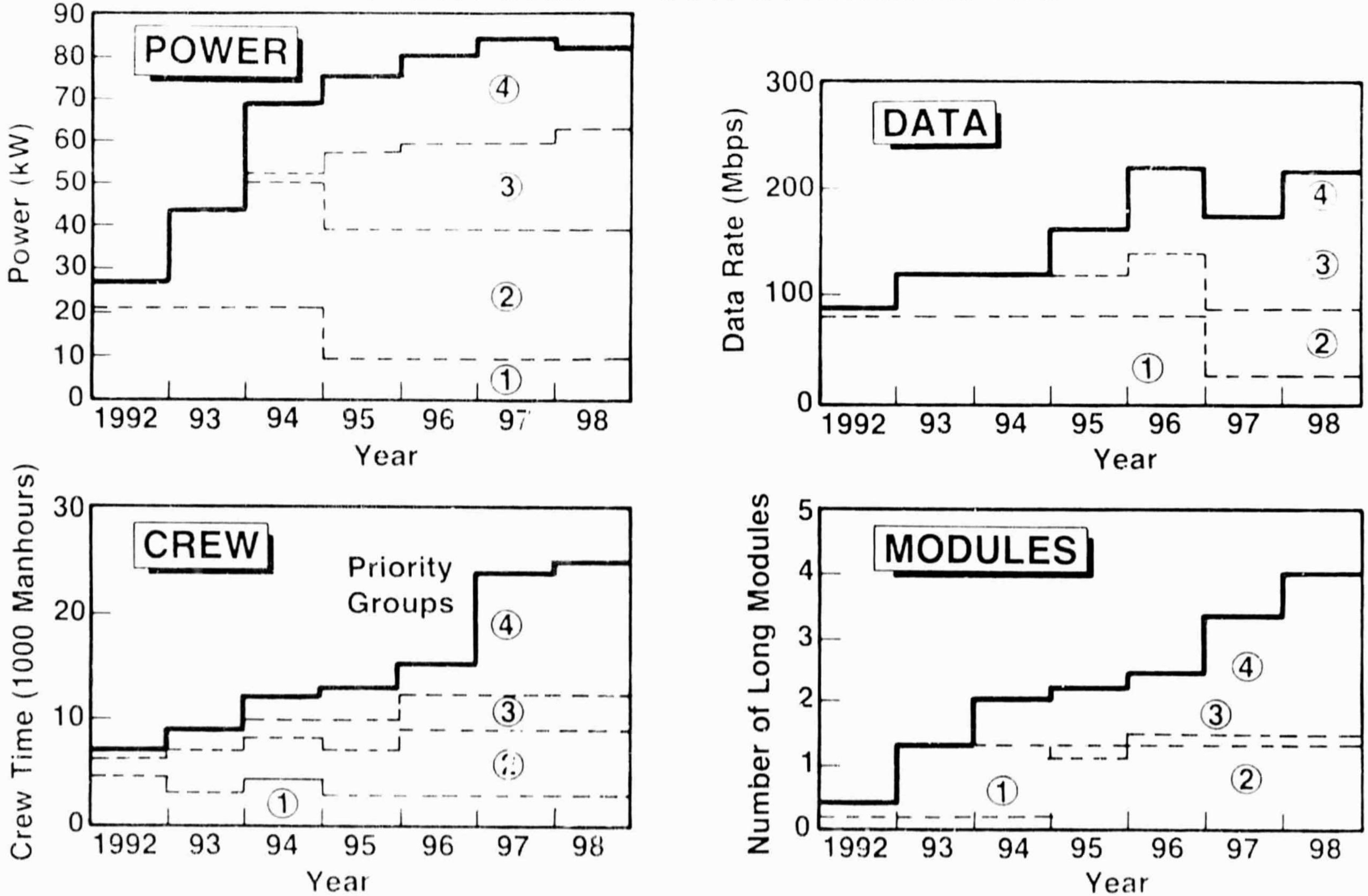


- Mission Capture 84
- Acceptable on Station 64
- Science/Applications Missions Acceptable on Platform 32

McDONNELL DOUGLAS

TIME-PHASED PRIORITIZED MISSION REQUIREMENTS

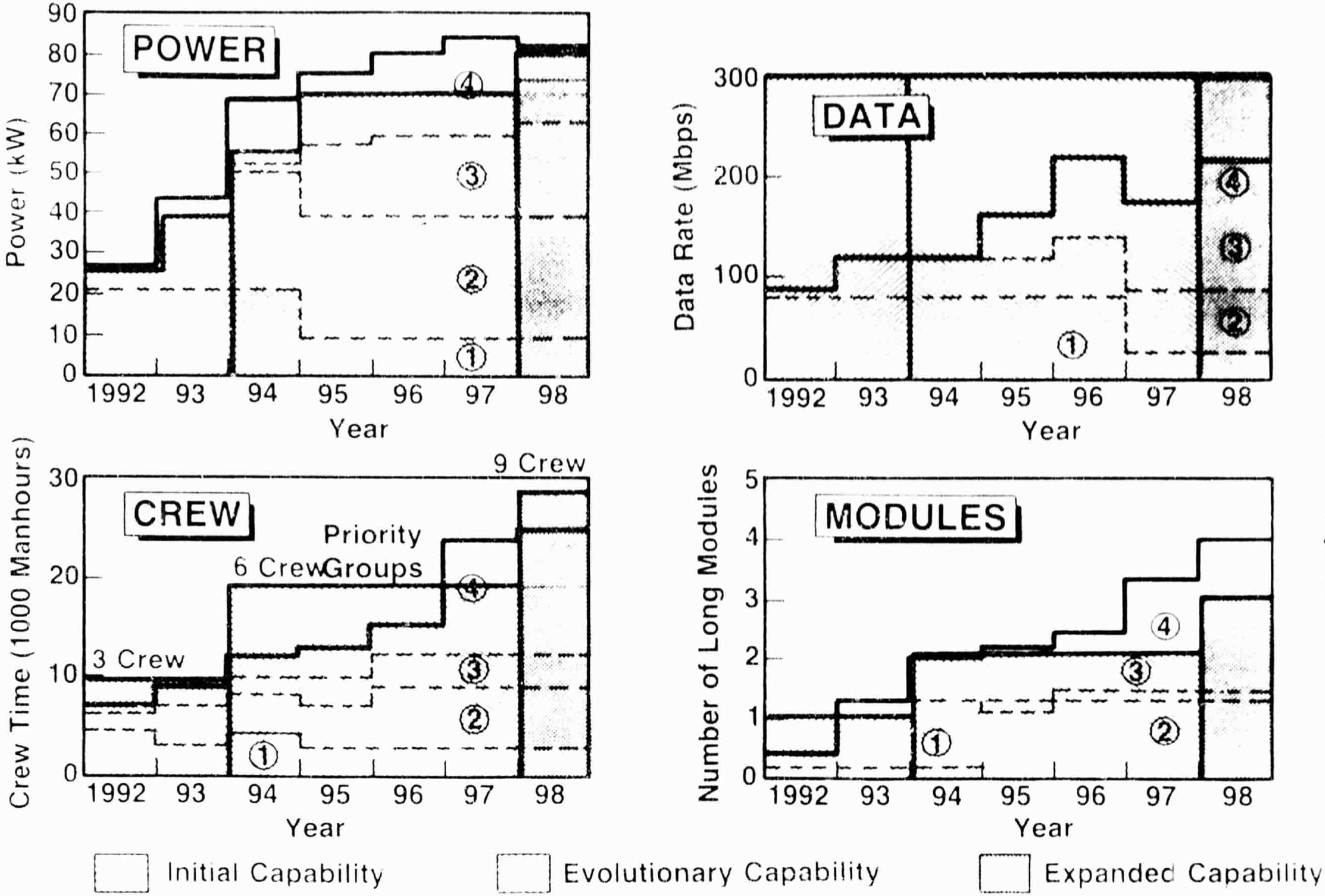
SPACE STATION — 28 deg
PLATFORM — SUN SYNCHRONOUS



McDONNELL DOUGLAS

TIME-PHASED PRIORITIZED MISSION REQUIREMENTS

SPACE STATION — 28 deg
PLATFORM — SUN SYNCHRONOUS



VGB708

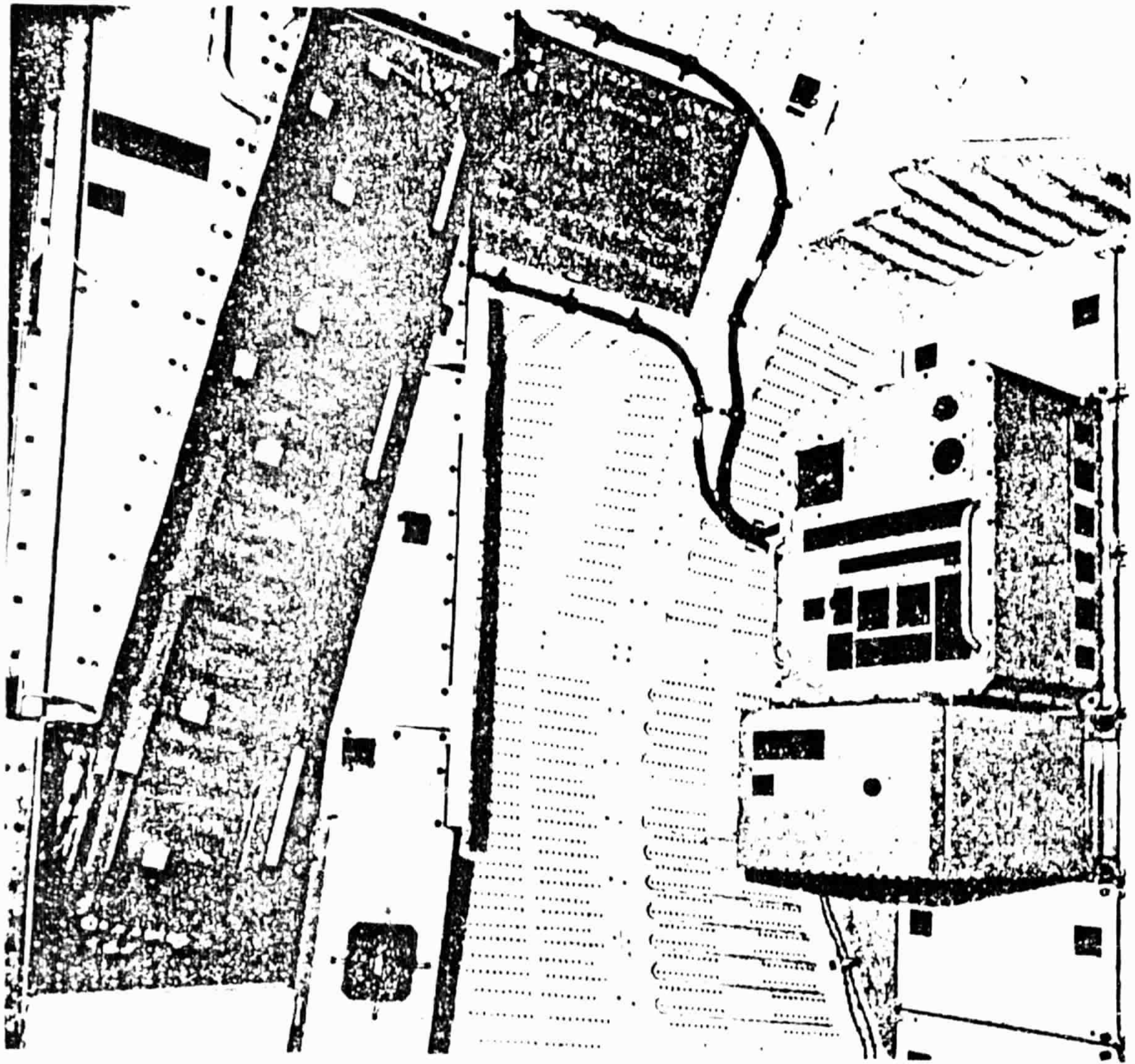
ATTRIBUTES OF A MANNED SPACE STATION

- Schedule Compression — Reduced Cost and Risk
- Combines Best Features of Unmanned Free-Flyer and Sortie Mission, e.g.,
  - Onboard Step-by-Step Development Sequence
  - Less Automation
  - Reduced Cost — No Free-Flyer Support Subsystems, Fewer Shuttle Launches
  - Common Support Equipment
  - Unlimited Data Gathering — Test Conduct Time — Flexibility
  - Infrequent Event — Seasonal Coverage
- Flight Crew Capabilities — Modifications/Repair/Replacement/Assembly
  - Visual Observations
  - Real-Time Sensor Adjustments
  - Analyzing Data
  - Pointing Control
  - Targets of Opportunity
  - Failure Diagnosis/Repair
  - EVA for Structural Assembly — Equipment Adjustments
  - Iterative Operations
  - Learning Curve Benefits

Man Responds Creatively as Unanticipated Events or Problems Arise

- Contribution of Man in Space is Historical Fact

EOS MIDDECK SYSTEM



Joint Endeavor Agreement

STS	Flight Dates		
4	July	1982	(Completed)
6	April	1983	
7	June	1983	
8	August	1983	
12	March	1984	
16	July	1984	

Results From STS 4

1. Yield Increased 500 Times
2. Repeatable Quantitative Separation Demonstrated
3. EOS Design Concept Validated
4. Value Manned Participation Confirmed

EOS HUMAN OPERATORS ACTIVITY
SHUTTLE MIDDECK TASKS
SCHEDULED OPERATOR CALLS

VGB371

Perform as Power Loadmaster

- Cycle Power On/Off as Required

Change System Operation

- Start/Stop
- Zero Check
- Process Sample
- Collect Sample

Take Photographs of Column

- Required 14X Each Day

Process Maintenance/Service

- Change Sample Input
- Change Collection Trays

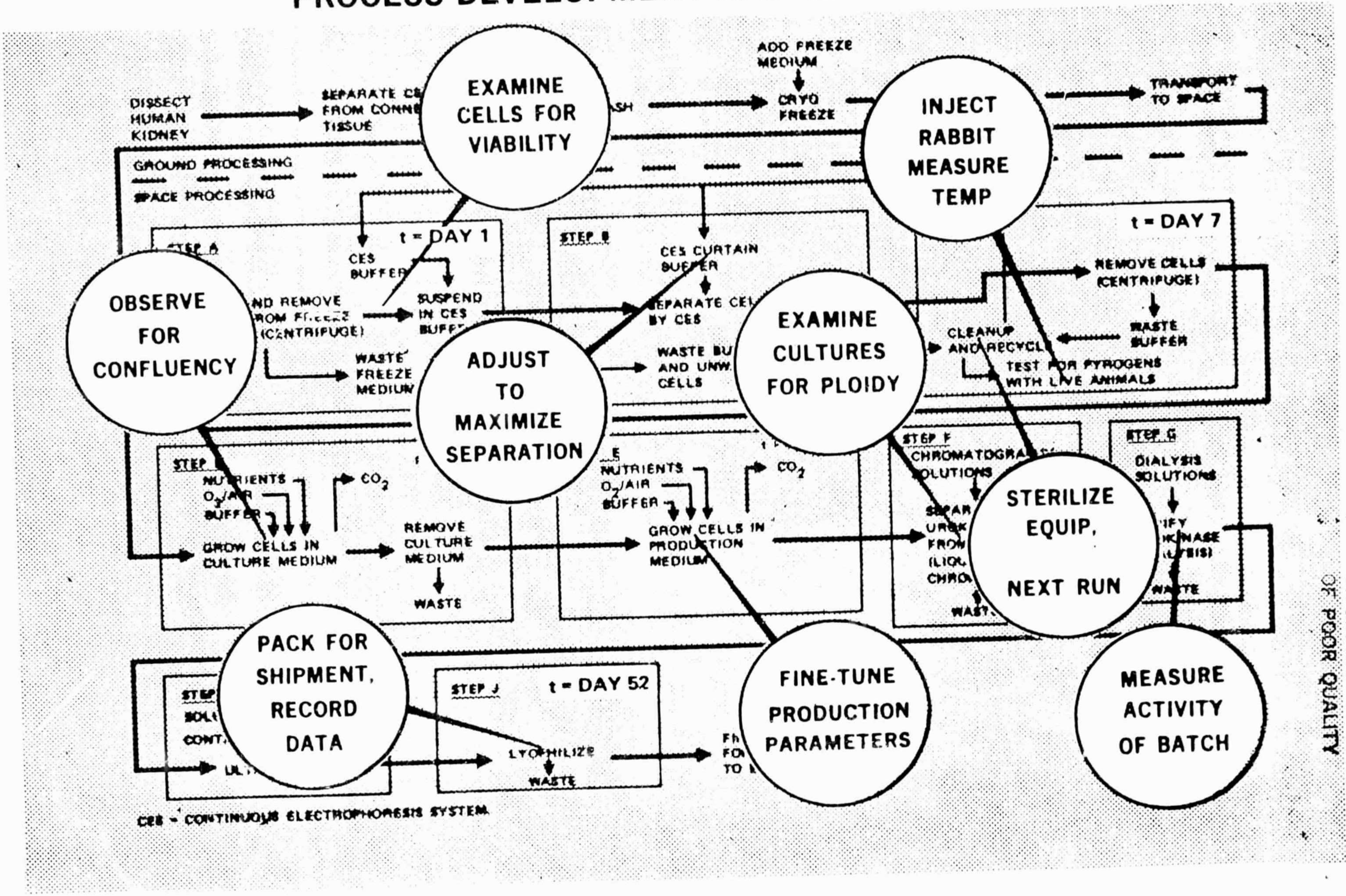
Product Stream Detection

- Observation is Possible but a Highly Skilled Mission Specialist is Required to Recognize and Interpret Pattern if Dye is Not Included With the Sample. Current Astronaut Training is Insufficient for Effective use of Information Obtained From Column Observation
- Shuttle Link to Ground-Based Mission Specialist Lacks Adequate Bandwidth for Useful Interaction Between Astronautics and Ground

Five Malfunctions Occurred During the STS-4 Flight, Four Process Out-of-Range Errors and a Mandatory Stop/Reset/Restart Software Problem. These Incidents Coupled With the Limited Ground Link Indicate That an Onboard Mission Specialist Would Significantly Increase the Efficiency of EOS Operations on Future Flights

ROLE OF MAN IN UROKINASE PROCESS DEVELOPMENT AND OPTIMIZATION

25703



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BENEFITS OF MAN IN SPACE — OCEANOGRAPHY

VFT744

- Interpretive Capability
- Color Acuity Far Above Any Other Sensor
- Flexible Response
- Interactive Processor
- Selective Data
- Data Compression
- Real Time Oceanography
- Special Sensor Deployment and Recovery
- Cheaper Way to Do Some Research Projects
- Definitive Site, Not Necessarily At NADIR
- Orbital Height Ideal for Mesoscale Feature Identification
- Legislates Against Bias Errors in the Data
- Reduces Likelihood of Total System Failure
- Communication Point for Up-Link and Down-Link Information Transfer

OCEANOGRAPHIC EFFECTS DISCOVERED FIRST FROM MANNED SPACECRAFT

VFT743

INTERNAL WAVES

- Distribution Along Shelf Break (Apollo 6)
- Configuration Over Shelf (Apollo 6)
- Existence in the Open Ocean (Skylab)
- Extent and Configuration Along Ocean Fronts (Skylab)

OCEAN SWELL

- Refraction and Absorbtion at Current Boundaries (Skylab)
- Refraction in Fjords (Skylab)
- Dissipation at Upwelling Boundaries (Skylab)

EDDIES

- Existence at Coastal Boundaries (Gemini)
- Size Variability in Confined Seas (Apollo)
- Distribution Along Current Edges (Skylab)
- Kelvin-Helmholtz and Von Karman Vortices — Island Wakes (Apollo and Skylab)
- Scale Variability (Skylab)
- Surface Manifestation of Warm and Cold Core Eddies (Skylab and ASTP)
- Coalescence (Skylab)
- Associated Cloud Formations (Skylab)

FRONTS

- Surface Manifestations of Fronts (Gemini — ASTP)
- Fronts and Thermal Boundaries (ASTP)
- Mesoscale Turbulence at Frontal Boundaries (Skylab)
- Plankton Distribution (Skylab)
- Wave/Front Interaction (Skylab)

UPWELLING

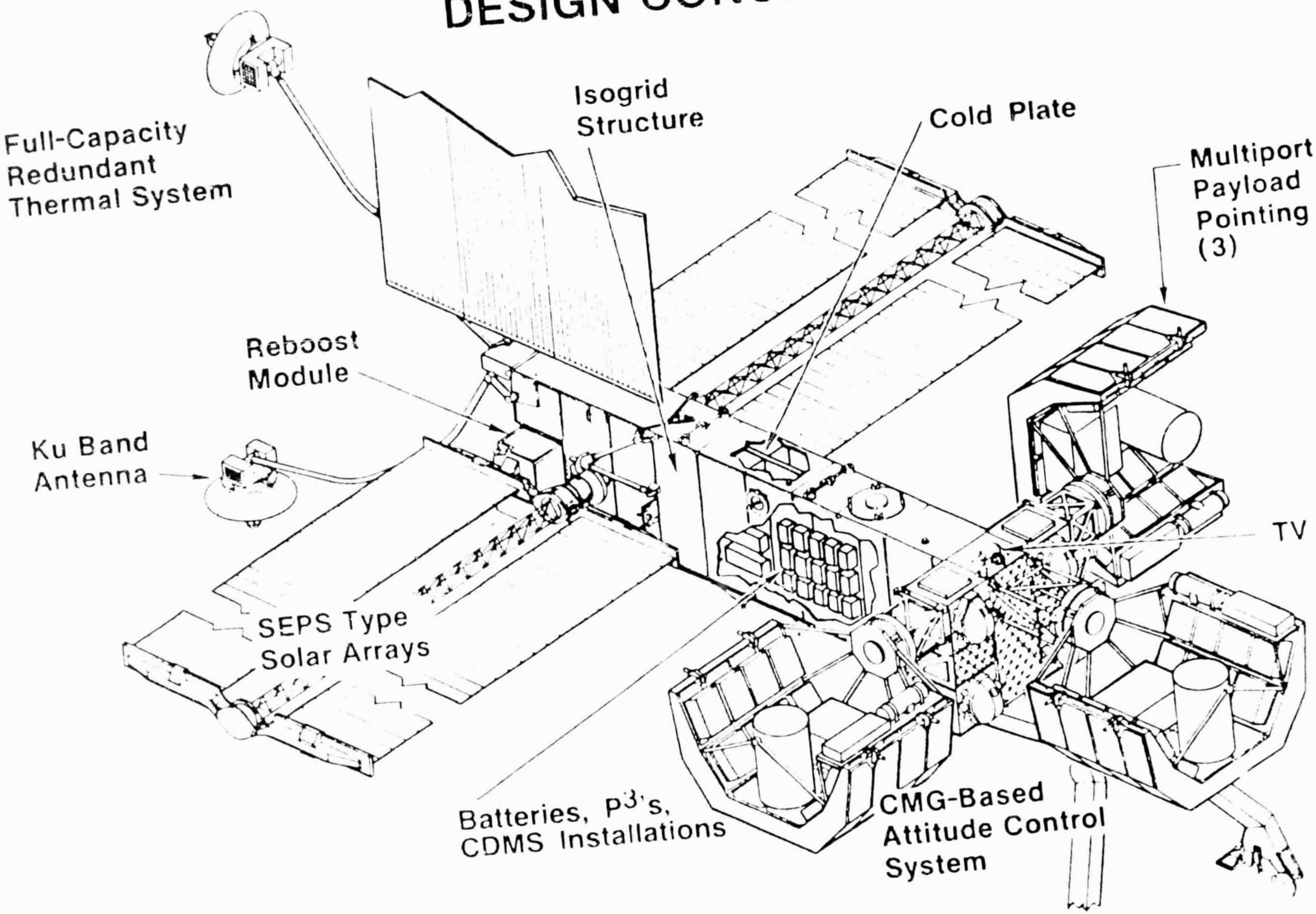
- Configuration of Upwelling Boundaries (Apollo, Skylab)

CURRENTS

- Current Confluence and Retention of Identity (Skylab)

VFT332

SPACE PLATFORM SYSTEM DESIGN CONCEPT



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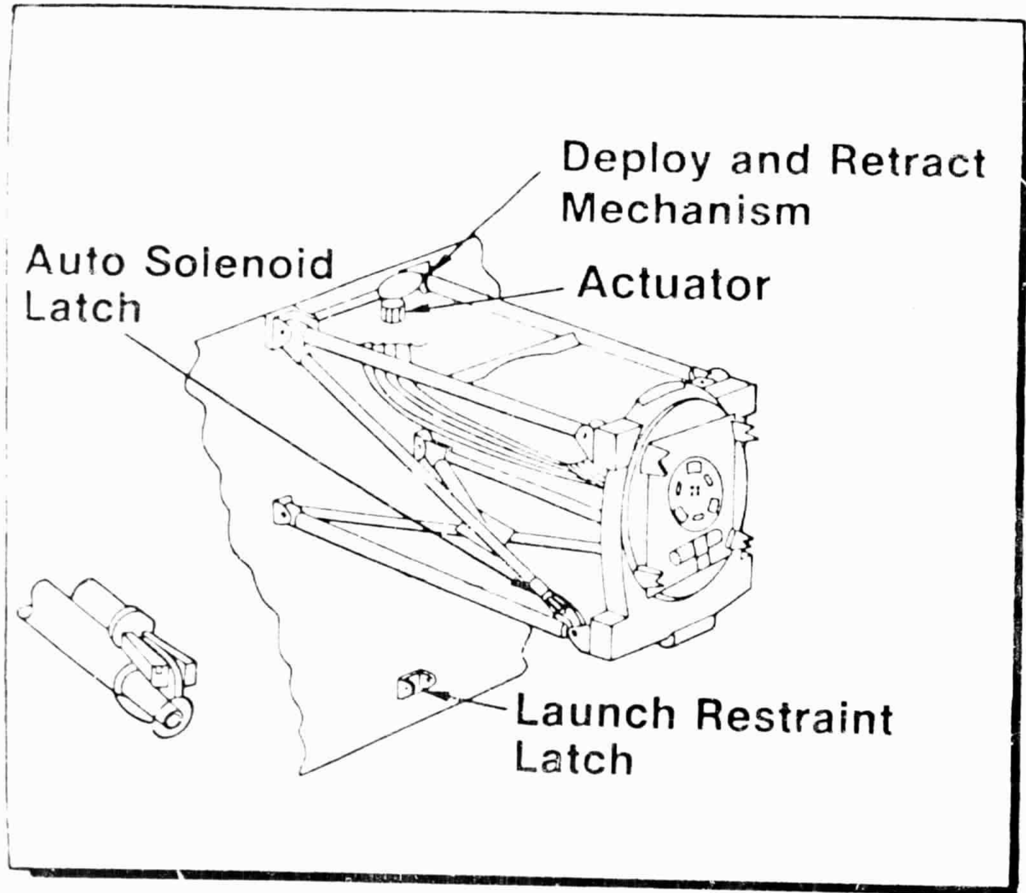
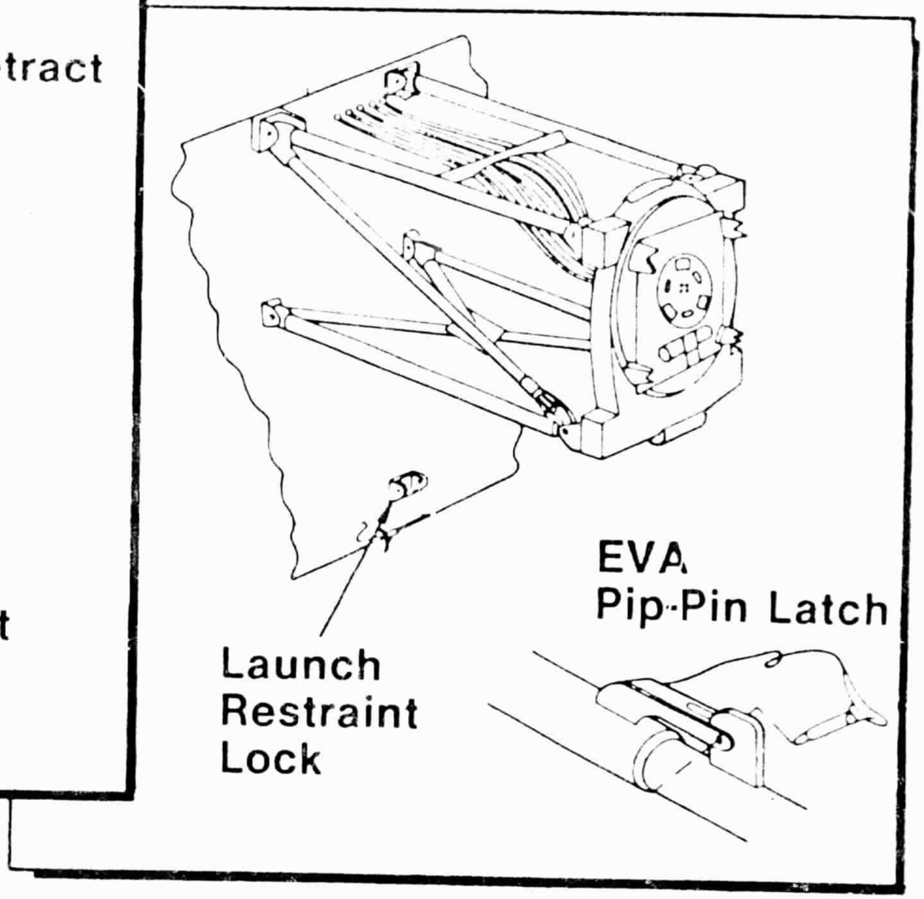
PAYLOAD BERTHING PORT (X-AXIS)

VGB352



Remotely Actuated Deployment Mechanism



Manually Actuated (EVA) Deployment Process

EVA VS MECHANISMS

VGB353

- Reduction of Automatic Mechanisms
  - Forward Launch Support — $133K
  - Solar Array Launch Latches — 1051K
  - Radiator Launch Restraints — 401K
  - +Y and -Y Berthing Port Mechanisms — 266K
  - Aft Berthing Port Mechanisms — 344K
  - Antenna Launch Latch — 211K

TOTAL COSTS FOR 15 MECHANISMS = $2406K

- Manual Activation to Perform the Functions of the Above-Stated Mechanisms Involves 2 EVA Crewman Approximately 2.5 Hours Which is Well Within the Capability of EVA Operations

EVA Costs (Per EVA Crewman) = $60K-100K, Depending on EVA Support Equipment*

$60K X 2 Crewman = $120K

$100K X 2 CREWMAN = $200K

*Per MMU Users Guide, Martin Marietta Report MCR-78-517 (Contract NAS9-14593)